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PAIN RESPONSE IN SCHIZOPHRENIC PATIENTS

by

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies for acceptance, a thesis entitled "Pain Response in Schizophrenic Patients" submitted by Eleanor Margaret Kane in partial fulfillment of the requirements for the degree of Master of Science.

ABSTRACT

Pain response in schizophrenic patients was investigated using thermal methods. Radiant heat applied to the forehead was the noxious stimulus. Schizophrenic patients were diagnosed as "process" or "reactive" by means of the Self - Report Scale (Ullmann and Giovannoni, 1964). The dependent variables were threshold report and pupillary response. Subjects were required to report detection of warmth (WDT), pain threshold (PT) and pain tolerance (PTO). Nonschizophrenic psychiatric patients and normal subjects constituted the control groups. Process schizophrenics evidenced reduced sensitivity in comparison to all other groups both in their sensory thresholds for pain and in their physiological response to a noxious physical stimulus. Reactive schizophrenics resembled normal subjects on both dependent variables. Nonschizophrenics resembled process schizophrenics in their sensory thresholds for pain but differed significantly from normal subjects in their pupillary response, evidencing reduced responsivity to a noxious stimulus.

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INTRODUCTION

Schizophrenia is one of the most prevalent and perplexing morbid conditions in our society. Statistical reports from clinics and hospitals attest to its widespread occurrence and voluminous literature bears witness to extensive research into its etiology, nosology and treatment. In the United States, 50% of all persons being treated for mental and emotional disturbances carry a diagnosis of some type of schizophrenia. (Lemkau and Crocetti, 1958). As a condition or group of conditions, the problem of schizophrenia remains to a significant extent unsolved.

Investigations into the nature of schizophrenia have essentially centered around one of the following conceptual models: the biological and genetic model which focuses on biological and/or genetic determinants for behaviors which are seen in patients classed as schizophrenic; the psychological model which attempts to discover a primary deficit in sensation, perception, and learning. In this latter area of investigation the bulk of research has been directed to the pathologies of language and thought. Detailed study of perceptual processes in schizophrenics has lagged far behind due mainly to the historical conception advanced by Bleuler (1911) that the classes of behavior labelled schizophrenic excluded disorders of the sensory processes. This may seem strange in view of the fact that schizophrenic patients have hallucinations. However, the early investigators tended to make a clear cut division between sensation ("sensorium") and perception, regarding the latter as due to cognitive or judgmental processes rather than to sensation. This view was consistent for years with a similarly outmoded view of sensation as a passive process, determined by external stimuli. As research in perception began to shift toward a view of perception as a creative

process, whereby the perceiver shapes and organizes the content of his experiences, so the psychopathologist revised his thinking about disorders of perception in clinical investigation.

Auditory and visual hallucinations, inaccuracies in perceptual judgments are now seen as examples of disorders of perception or, at best, misperceptions. Attention has been directed then, to the area of perception in an effort to determine the variables which may determine these misperceptions.

Comparative investigations of schizophrenics and normals into differences in threshold perceptions in the various sense modalities have produced the following results. No reliable differences exist between schizophrenics and normals in the critical flicker fusion threshold (McDonough, 1960). No perceptual differences in visual acuity have been reported between schizophrenics and normals. Investigations into the phenomenon of apparent movement have shown that undifferentiated schizophrenic patients see apparent movement at a much lower rate of oscillation than normals. However when this group of patients is further differentiated into paranoid and nonparanoid groups, the paranoid patients are equal in performance to normals (Saucer, 1958,1959).

Experiments on auditory thresholds have failed to demonstrate differences between schizophrenics and normals (Travis, 1926). No differences in thresholds for tactile perception have been reported between schizophrenics and normals. Huston (1934), using direct current stimulation, found sensory thresholds did not differ for these two groups.

Pain, when seen as a biological adaptive or regulating mechanism protecting the organism from undue harm, gains significance as a research

problem in psychology. Pain acts as both a cue, in alerting the organism, and as a motivating factor in arousing the organism to an appropriate adaptive response. The experience of pain depends both on the intactness of relatively simple and primitive neural fibers, and on more integrative cortical functions. The subjective experience of pain and the behavioral reaction to it are determined by such higher psychological processes as arousal, attention, and the total affective and emotional state of the individual (Hall, 1954). Animal research (Thompson and Melzack, 1956) indicates that an interruption of early learning experiences in dogs produces undirected, maladaptive reactions to painful stimuli.

The sensation of pain may be defined as a reaction, biological and/or psychological, to a noxious stimulus. Schizophrenics tend to be less sensitive (that is, less reactive) to a variety of physical and biological stimuli (Hoskins, 1946). They appear to be less prone to allergenics, tolerate much higher doses of such drugs as histamines and hallucinogens (Weckowicz and Hall, 1958; Hoffer and Osmond, 1968).

Clinical descriptions of aberrant reactions to physical stimuli ordinarily experienced as painful are not uncommon in case histories of hospitalized schizophrenics.

> "Carol has a lifelong history of insensitivity to physical pain, which at times was and is a medical hazard. Her parents reported on one occasion that no one was aware of her having a serious middle ear infection (normally very painful) until her eardrum burst to permit the exudation of pus. Similarly, at the center, she developed a severely abscessed tooth, with swollen face and fever, but gave no evidence of stress to the presumed pain."
>
> p.780
>
> (Goldfard, 1958)

The perception of pain, when viewed as an adaptive device whereby the organism maintains itself relatively free from injury or harm, merits investigation in psychiatric conditions.

The problem of measurement and quantification of thresholds for pain in normal subjects has been very thoroughly investigated since the first paper by Hardy, Wolff and Goodell (1940) in which they reintroduced thermal methods for producing cutaneous pain. Their very extensive research since that time is collected in a text, Pain Sensations and Reactions (1952). In 1947 Hardy and his collaborators constructed a pain scale known as the "dol" scale of pain intensity which was based upon the discrimination of differences in intensity of measurable pain stimuli. Their very extensive research using this thermal method established it as standard procedure for the following reasons:

1. The intensity of the stimulating agent can be precisely measured.
2. The sensory threshold for pain obtained from a thermal stimulus is said to be a sharply defined experience thus allowing for a higher degree of accuracy in threshold determination than is available with other methods.
3. The method is flexible in that time of exposure to the stimulus, area and state of the skin, can be varied at will.

In experimenting on themselves over a period of a year, the authors reported a high degree of uniformity in the pain threshold, and also a very close agreement amongst themselves.

However, subsequent investigations of normal pain threshold have produced conflicting results. Schumacher, Goodell, Hardy and Wolff (1940) maintain that pain perception threshold is uniform in normal subjects. Nevertheless, this uniformity of threshold was maintained only in so far as the subject was capable of maintaining an 'objective'

attitude toward the stimulus situation. Clearly then, the generality of this finding is limited.

Other experimenters (Chapman and Jones, 1944: Clausen and King, 1950) have reported much greater variability in determinations of pain threshold in normal subjects. The suggested factors producing this variability were age, sex, intelligence and particularly, the ability to introspect.

Investigations on pain threshold in psychiatric patients have been mainly conducted on psychoneurotic patients. Hall (1953) reviews this work and cites the general conclusion from these studies that neurotics tend to react much earlier to pain than normals.

A number of studies by Malmo and colleagues from the Allan Memorial Institute of Psychiatry, Montreal, have focused on the problem of reactivity to pain in psychoneurotics. Recordings of various psychophysiological responses were made on patients during thermal stimulation to the forehead. Psychoneurotics tended to over-react at both a motor and an autonomic level of response. (Malmo, Shagass, Davis, Cleghorn, Graham, and Goodman, 1948; Malmo and Shagass, 1949; Malmo and Shagass, 1952). Anxiety, as a symptom of psychoneurosis, was considered instrumental in producing a higher level of physiologic disturbance to stress than was found in normals in whom anxiety was absent or secondary. Pathological anxiety was felt to be associated with a heightened state of expectation, which in turn was reflected in overreaction to stimulation.

Previous research on psychotics has been carried out almost exclusively on physiological reactions to painful stimuli. Malmo, Shagass and Smith (1951) found that early schizophrenics tended to

show a high degree of reactivity (measured EMG, heart rate, respiratory rate, blood pressure) to pain stimuli whereas chronic schizophrenics showed rather low responsiveness. That is, early schizophrenics resembled psychoneurotics in their responses to stress. This data was interpreted by Malmo et.al. in conjunction with Pfister's (1938) finding of heightened cardiovascular response in the early stages of schizophrenia. Pfister found that as schizophrenia progressed toward chronicity, reactivity became less and less, until finally the schizophrenic was more sluggish than normal in his cardiovascular response. Despite the fact that Malmo et.al. found that measures of background physiological activity were as high for chronic schizophrenics as for other groups, the results for this group were interpreted as reduced reactivity on a muscular level alone as measured by EMG. This interpretation seems to ignore the perceptual-conceptual aspects of the response which are at least of equal importance in pain research.

Hall and Stride (1954) investigated response to pain in a large group of psychiatric patients which included a sample of 14 schizophrenic patients. Sensitivity to pain, as verbalized by the patients, was higher than normals as were their pain reaction point values. Their results were interpreted with caution as the authors felt that the lack of adequate directed response to the painful stimuli may have been due to a perceptual-conceptual misinterpretation of the stimuli. Mention was also made of the unreliability of the mental set of these subjects.

Ray (1963) compared groups of chronic schizophrenics who were classified on the basis of "adequate" versus "inadequate" overt verbal behavior. Using GSR, he found these groups as well as normal controls reacted automatically to affective verbal stimuli when verbal responses were required, but differential GSRs were diminished or absent in

patients when overt responses were not required. This data are very difficult to interpret as Ray does not clarify the basis for classification, nor does he specify the nature of the stimuli.

Petrie (1967) formulated a three-type classification for describing responses to sensory input, including noxious stimulation. "Augmenters" are those individuals who evidence heightened sensitivity to pain stimulation. Because of their tendency to amplify sensory input, they tend to be intolerant of suffering from pain. "Moderates" are defined as those individuals who do not show extreme reactions to painful stimuli, that is they do not either amplify or reduce sensory input to any extent. "Reducers" are individuals who show considerable tolerance for pain, presumably because they reduce the sensory input. This scheme represents a continuum of perceptual reactance with "augmenters" and "reducers" at the extremes. Petrie also suggests another dimension, that of sensation, where at one end lies sensory excess (which would include noxious stimuli) and at the other end lies sensory lack (sensory deprivation). Degree of augmentation or reduction is determined by a Kinesthetic Figural After-effects test (KFA).

Petrie demonstrated extreme reduction on a KFA task with a group of 17 schizophrenic patients as compared with normal controls. She postulates that there is a restriction on intake from the environment during the illness, and that this restriction is defensive in nature as the schizophrenic suffers from an excess of sensory bombardment (biological noise). Support for this notion comes from studies demonstrating high resting levels on physiological measures (Buss and Lang, 1965). Petrie suggests that central nervous system modulation upon sensory input is disrupted in schizophrenic patients. It is because the schizophrenic suffers initially from excessive sensory

bombardment that he defensively reduces the impact of sensory stimulation during such experimental procedures as KFA.

Silverman (1964) found support for Petrie's classification scheme in a study using the KFA procedure with paranoid and nonparanoid schizophrenics. Statistically significant differences were found between the two groups; stimulus intensity reduction responses were more common among paranoid than among nonparanoid schizophrenics.

It is essential to mention here a problem which is encountered in much of the research in perception, namely that of report validity. Traditional methods of determining sensory thresholds have recently encountered much criticism. The term "response bias" refers to the possible factors which may influence a subject in making threshold judgments, and includes such factors as attitude, motivation, payoff. Proponents of "signal detection theory" maintain that the observer's subjective standard or criterion for reporting the presence or absence of a sensation influences the obtained value of the threshold, and that this criterion cannot be considered constant across subjects (Swets, Tanner and Birdsall, 1961). These critics propose Signal-Detection methodology as an alternative which reduces the influence of this variability. However, Natsoulas (1967) suggest use of an involuntary autonomic response along with threshold judgments as a means of establishing report validity. Since autonomic reaction is part of the organism's total reaction to the painful stimulus, an involuntary autonomic response could be used as an additional indication of the subject's experience of pain along with his verbal report.

Pupillary dilation and constriction is viewed as a highly integrated biological regulatory process, not just as a simple reflex (Gebhard, 1959). Pupillary changes are known to occur with such psychic

stimuli as surprise and fear (Lowenstein and Friedman, 1942). Rubin (1960) examined directly the relationship between pupillary reactivity and the adrenergic-cholinergic mechanism in normal subjects and psychotic patients. Following Cannon's Emergency Theory of Emotion, Rubin argues that maximal generalized sympathetic activity follows immediately upon a sudden stress, emotional or biological, and that this activity is functionally adaptive. His hypothesis is that this maximal sympathetic activity following perception of threat is facilitated by a decrease in parasympathetic outflow in normal individuals. Rubin used pupillary dilation as a physiological measure of the sympathetic (adrenergic) mechanism and pupillary constriction as a measure of the parasympathetic (cholinergic) mechanism. The cold pressor test constituted the physiological stress and this produced signigicant increases in pupillary dilation, supporting the hypothesis that under a condition of stress, the normal reaction is for an increased adrenergic outflow. The significant decrease found in the level of constriction of the pupil under the cold pressor condition suggested a decreased cholinergic outflow in normals under stress. The reciprocity of the adrenergic-cholinergic components was thought to insure maximal mobilization of the organism for adaptive responses.

In addition, Rubin tested the hypothesis that the functional psychoses may be characterized by disordered responses to stress, and that these would be reflected in significant departures from the adrenergic increase and cholinergic decrease which was exhibited by normals subjects. The experiments confirmed the existence of specific patterns of adrenergic-cholinergic interaction which significantly differentiated psychiatric patients from normals. The patterns of disordered responsiveness to stress demonstrated an impairment of

either the adrenergic or cholinergic mechanism or both.

Streltsova (1955), a Russian investigator conducted systematic studies on the response of pupil dilation under stimulation. She found the majority of her schizophrenic patients showed little or no reactivity to hot or cold tactile stimuli, an odor or a bell. These results were interpreted in Pavlovian terminology as due to excessive amounts of inhibition which were experienced by these subjects. May (1948) also found diminished pupillary sensitivity to a pain stimulus in schizophrenia.

It is now generally agreed upon that one reason why many experimental findings on schizophrenic patients are contradictory is the fact that these patients as a category constitute a rather heterogenous group. One important dimension of schizophrenia is that of "process" versus "reactive". A major difference between the process and reactive groups is that the reactives are marked by a sudden onset of schizophrenic behavior, with little or no history of prepsychotic pathology and have a favorable prognosis for recovery. These patients display marked anxiety and a heightened affective response. Process schizophrenics, on the other hand, are marked by a long history of psychological difficulties, insidious onset of symptoms, a flatness of affect and poor prognosis for recovery. Becker (1959) suggests that it is more appropriate to consider "process - reactive" as a dimension rather than as two disparate diagnostic categories.

Higgins (1964) presents a very comprehensive review of research related to the process-reactive classification. There appears to be sufficient justification from studies in perception, cognition, motivation and learning to employ this dimension of schizophrenia in experimental research.

The measurement of the process-reactive dimension usually has been based on either the Phillips (1953) or Elgin (Wittman, 1941) scale. Both depend on interview and case-history material and have the disadvantage of being time-consuming. Recognizing this problem Ullmann and Giovannoni (1964) developed a 24 item self-report scale designed to facilitate measurement of the process-reactive continuum. The items of the scale deal with behavior evidencing interaction with the environment.

In a validational study, Johnson and Ries (1967) correlated the self-report scale with ratings derived from the Premorbid subscale of the Phillips Prognostic Rating Scale. Using two samples of male schizophrenics, the correlations found were - .75 and - .58.[1] The authors concluded the correlations justified use of the scale for differentiating schizophrenics along the process-reactive continuum. Use of the scale was also made by Ullmann and Eck (1965) in a study investigating Rorschach perception.

The Problem:

The present study investigated response to thermal stimulation comparing the reactions of schizophrenics and normals. The schizophrenic patients were differentiated along the process-reactive dimension using the Ullmann and Giovannoni Self-Report scale. A group of non-schizophrenic psychiatric patients was included as a control. Results from these groups were compared with a sample of normal subjects.

A subject was required to report verbally the following features

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[1] The negative correlation refers to the fact that a high score on one scale corresponds to a low score on the other scale.

of his sensations:

1. The first point at which any feeling of warmth was detected.
2. The point at which the subject experienced a pricking or jabbing sensation.
3. The point at which the subject wished to have the stimulus terminated.

These stages were designated respectively as Warmth Detection Threshold. (WDT),Pain Threshold, (PT), Pain Tolerance, (PTO).

Pupillary responses were recorded continuously during the experimental session and analyzed subsequently to determine amount of pupillary dilation with each increase in radiant heat.

It was predicted that process schizophrenics would demonstrate elevated Pain Threshold and Pain Tolerance levels compared to normal subjects, this prediction based on the results from numerous studies (summarized by Buss and Lang, 1965) demonstrating reduced responsiveness to a wide variety of stimulating agents.

Reactive schizophrenics were expected to resemble anxiety neurotics (Hall and Stride, 1954) in their responses, that is, reporting pain threshold and pain tolerance earlier than normal subjects. The non-schizophrenic psychiatric patients were expected to resemble normal subjects in their verbal reports.

It was anticipated that analysis of the data on pupillary responses would shed light on some theoretical considerations. The term 'withdrawal' in schizophrenia may denote two different things:

1. It may mean withdrawal on a conscious level only. The patient remains biologically sensitive to the environment but represses the awareness of it to

defend himself from excessive amounts of stimuli which, to him, are psychologically threatening.

2. The term may also refer to both reduced awareness of stimuli and diminished physiological reactivity to them. The patient is less responsive on a biological level and also appears withdrawn on a psychological level.

It was proposed that 'withdrawal' in process schizophrenics includes both reduced awareness and diminished biological reactivity and therefore, results should demonstrate reduced pupil responsivity in this group. Prediction of pupil responsivity also was derived from a suggestion made by Weckowicz (1958). After investigating autonomic responsivity in schizophrenia using the mecholyl test, Weckowicz proposed that parasympathetic activity is impaired in acute schizophrenics, while in the chronic stage of the disease impairment shifts to sympathetic activity. Since the dilator pupillae is innervated by sympathetic fibers from the cervical ganglion, impairment in sympathetic activity should be reflected in diminished pupillary response in process schizophrenics. Rubin (1960) would also predict diminished pupillary responsivity for this group due to impairments in the adrenergic-cholinergic mechanisms.

As far as the reactive schizophrenics were concerned, even if the prediction of a lowered sensory pain threshold should not be confirmed it could be expected that, because of the high arousal of these patients, the pupillary (physiological) reaction to noxious stimuli would be enhanced or at least the same as in the controls.

METHOD

Sample

Psychiatric patients were available for research purposes at Alberta Hospital, Edmonton. The sample consisted of 15 process schizophrenics, 15 reactive schizophrenics, 15 non-schizophrenic psychiatric patients and 15 normal subjects.

Normal subjects were students enrolled in the Introductory Psychology course at The University of Alberta, Edmonton. Subjects earned one credit for participating in the experiment and this credit contributed to their final grade for the course. The mean age for this group was 21.6 years (S.D. = 1.4 years).

The Self-Report Scale (Ullmann & Giovannoni, 1964) was administered to a group of 44 schizophrenic patients (7 of whom were discarded from the sample due to incomplete Scales). Fifteen patients were selected whose scores fell between 1 and 12 and these were classified as "process schizophrenic". Fifteen patients were selected whose scores fell between 13 and 24 and these were classified as "reactive schizophrenic".

The process schizophrenics fell into the following diagnostic categories: 3 simple, 3 catatonic, 4 hebephrenic, 5 undifferentiated. The mean age for this group was 35.7 years (S.D. = 4.5. years). The mean length of hospitalization was 63.2 months (S.D. = 40.4 months).

The reactive schizophrenics fell into the following diagnostic categories: 6 undifferentiated, 3 simple, 5 schizophrenic reaction, 1 catatonic. The mean age for this group was 33.1 years (S.D. = 6.1 years). The mean length of hospitalization was 8.6 months (S.D. = 5.8 months).

The non-schizophrenic psychiatric patients were selected on the basis of complete absence of any schizophrenic illness in their history. These patients fell into the following diagnostic categories: 2 psychopaths, 7 alcoholics, 3 psycho-neurotics, 3 behavior disorders. The mean age for this group was 32.7 years (S.D. = 8.1 years). The mean length of hospitalization was 9.6 months (S.D. = 8.1 years). The mean length of hospitalization was 9.6 months (S.D. = 5.4 months).

Patients diagnosed as "paranoid schizophrenic" were excluded from the sample as many investigators have found this group to differ from other classes of schizophrenia on a majority of measures. Shakow (1962) has summarized many years of research into schizophrenia with the observation that the paranoid patient resembles the normal control more often than he resembles other classes of schizophrenia in experimental research.

Medication was discontinued three days prior to testing each patient in the sample, except on such drugs as were necessary for maintenance of physical health, for example, insulin. Excluded from the sample were those patients on electroconvulsive therapy, patients diagnosed as mental defectives and those thought to be suffering from organic brain pathology.

All participants in this study were male. There is evidence that female subjects of comparable age and clinical category report pain at a different point than males (Hall & Stride, 1954).

A maximum age of 44 years was set as one criterion of subject selection as there is evidence that overall pain sensitivity declines after the late fifties. Forehead sensitivity is stable up to the middle forties but then becomes significantly poorer (Schluderman & Zubek, 1962).

It was not possible to match the subjects according to age. A t test of the means revealed all psychiatric patients differed significantly from normal subjects. However, this difference in light of the above consideration of pain sensitivity is not meaningful. No significant differences in age between psychiatric groups was found.

Psychiatric groups were not matched according to length of stay in hospital. t test of means revealed that process schizophrenics differed significantly from reactive schizophrenics and from nonschizophrenics on this variable. No other significant differences were found.

Apparatus and Materials

Psychiatric patients were tested in random order in a small windowless room at the hospital. The dimensions of the room were 12' x 9'9" x 8'5" and it was painted a flat white color. The mean room temperature was 73.6 degrees Fahrenheit. Normal subjects were tested in an experimental laboratory at the University. The mean temperature of this room was 71.6 degrees.

Subjects were seated at a table upon which rested a plywood box with an opening at one end large enough to admit the head. Subject's chin rested on a foam rubber pad.

The apparatus for producing radiant heat consisted of a 1000 watt projection lamp mounted on a stand 16 3/4 inches from the forehead position of subject. Light from this lamp was focused by a system of condensing lenses through a fixed aperture so that an area of approximately 3.5 cm^2 of blackened skin could be exposed. A shutter, activated by a timing device, was placed between the condensing lenses and this served to regulate the light source. The intensity of light was regulated by a variac and fixed variac settings were used for each

subject. Subject, when seated, faced a black cross drawn on a white background, which served as a fixation point. A small mirror placed at 45 degrees angle in the apparatus and across subject's line of vision permitted filming of the eye at a rate of 5 frames per second. Illumination for photography was provided by a 2.5 watt bulb on rheostat control which was placed at the bottom of the apparatus. Level of illumination was constant for all subjects.

A Beauleau 16 R movie camera with a 50 mm. lens was locked into position on one side of the box and the camera action was initiated by a timing device. 16mm. film was used.

The light source and camera were connected to a system of timers to produce the following sequence of events:

1. Camera action began 2 seconds before shutter opened.
2. Shutter remained open for 3 seconds, allowing light to fall on subject's forehead.
3. Camera action continued for 2 seconds following closure of shutter.

The eye was filmed continuously then for a period of 7 seconds. The interval between stimulus presentations (60 seconds) was also regulated by a timer. A white hospital screen prevented subject from viewing the apparatus and experimenter. Figure 1 displays the apparatus used in this study.

Forehead skin temperature was recorded by a thermistor probe 3/8 inches in diameter which was attached to subject's forehead. Temperatures were read from a transistorized tele-thermometer.

Procedure

Subject was seated facing the apparatus and Part A of the

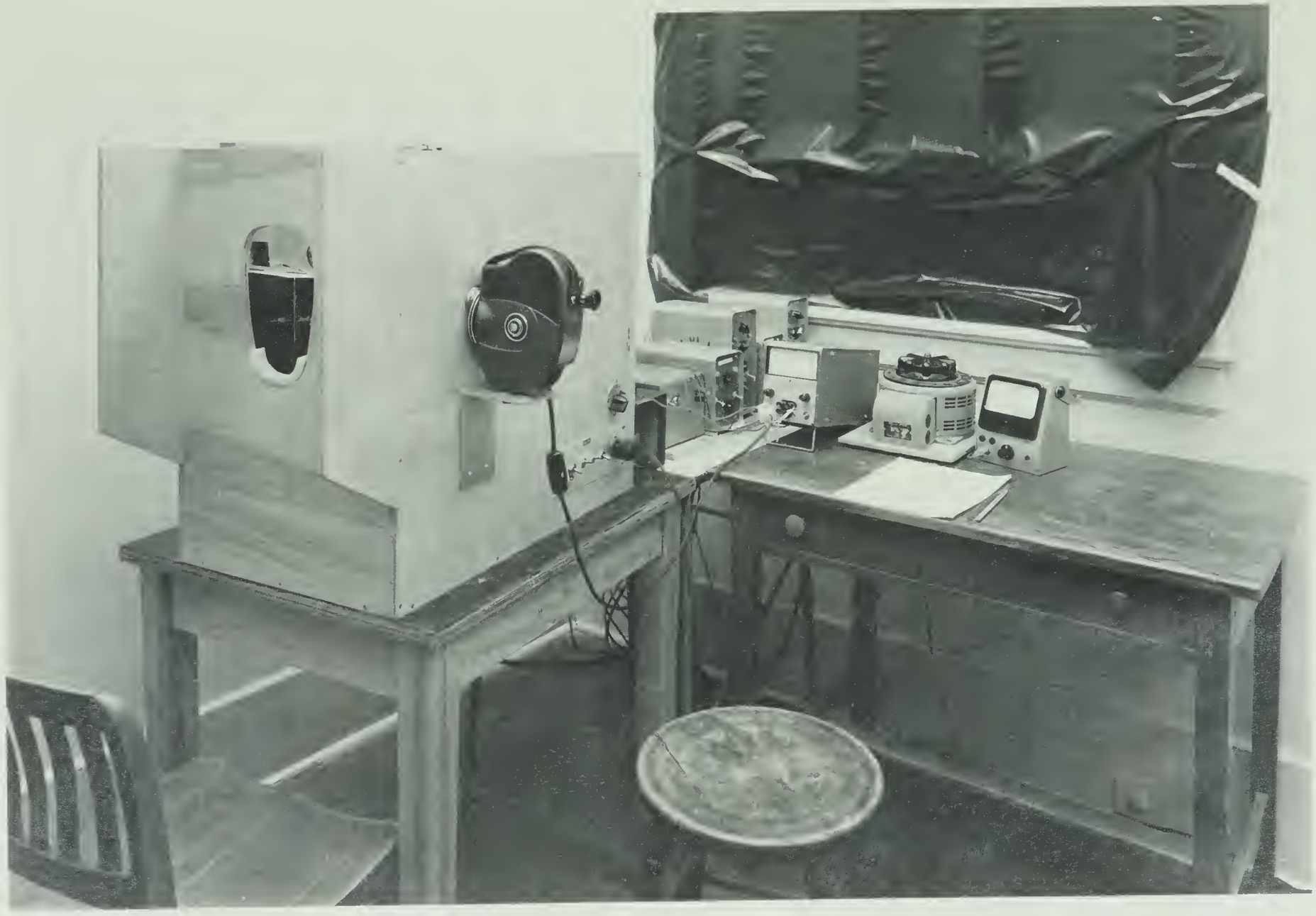


Figure I

APPARATUS

instructions were read to him (see Appendix B). A small area of the forehead was then blackened with an even coating of drawing ink to insure maximal absorption of radiation. The light source was switched on at this point and set at the first stimulus intensity, in order to allow time for thorough heating of lamp filaments.

The temperature probe was attached to the forehead by means of adhesive and the initial skin temperature was recorded. The average forehead temperature for each group was as follows: Normals 91.83. Process schizophrenics 92.63. Reactive schizophrenics 91.73. Nonschizophrenics 91.70. There was no significant difference between these groups on initial skin temperature. Part B of the instructions was then read to the subjects.

Stimulus intensity was increased by standard units by regulating the intensity of illumination of the light source. Because it was not possible to accurately calibrate the light sources, the relationship between stimulus intensity and heat intensity was neither constant nor linear. Therefore skin temperature was taken to represent stimulus intensity and as such became the independent variable in the experiment. Skin temperature was recorded immediately after the shutter closed on each stimulus presentation.

The experimenter was able to watch the subject's face through the camera viewer, to detect any possible interruptions in experimental procedure. Each verbal report given by subject was recorded along with the number of the stimulus presentation at which it occurred. If the subject did not report PTO, the session ended arbitrarily when the stimulus maximum was reached. This maximum point was below the level of heat intensity which would produce tissue damage (forehead skin temperature 112-113 degrees Fahrenheit).

At the conclusion of the experimental session, subject's forehead was cleansed and questions about the experiment and apparatus were all answered.

Scoring

In psychophysical determinations of threshold judgments, increasing as well as decreasing stimulus intensities are used in the procedure. This method was employed in the present study, however, the results of the descending series were not considered in the analysis. The stimulus intensity could not be increased above the point where subjects reported PTO, leaving only one determination for this variable.

Using a 16mm. film strip projector, processed film was projected frame by frame onto a ruled sheet of mm. graph paper. Distance from projector to screen was 8ft. 5in. Diameter of the pupil was measured at its widest point for each measurable frame and recorded on a graph, providing plots for each stimulus presentation.

A resting level or baseline measure for each subject was determined by computing the average pupil diameter for the first stimulus presentation. All subsequent measures were converted into difference scores, indicating amount of pupil dilation from the baseline score.

Skin temperature values were also converted into difference scores, using the initial skin temperature before stimulation as a baseline measure. These difference scores were then converted into logarithmic units for the data analysis on the theoretical assumption that physiological responses to physical stimuli can be plotted as a Fechnerian (logarithmic) function; that is, the stimulus changes as a log, while the response changes arithmetically.

Detailed analysis was completed on pupillary responses by determining the magnitude (MAG) and latency (LAT) of these responses for each

threshold report. LAT was measured in seconds from the point of stimulus onset until the maximum response occurred within a particular stimulus presentation.

A second measure, the maximum pupillary response occurring throughout the entire session (MAX) was taken and plotted graphically to represent its relation to threshold reports for the different groups.

Three standard values of the physical stimulus (heat as measured by skin temperature) were chosen and designated at T_1, T_2, and T_3. These points represented temperature increases above the initial skin temperature of 1.0, 5.0 and 10.0 degrees Fahrenheit respectively. Pupil dilation was recorded at each point.

Experimental Design and Analysis of the Data

The dependent variables in this experiment were pupillary response and verbal report of thresholds. Psychiatric classification was treated as an organismic variable. The scores obtained on the dependent variables were submitted to an analysis of variance. Analysis was also made of the pupillary diameter baseline scores. Pearson correlation coefficients were calculated to determine the degree of correspondence between pupillary response and verbal report of threshold. A summary of the raw data appears in Appendix H.

Reference is made in the proceeding section to unequal ns in the different groups. The reason for this is that a subject may have failed to report one or more of the thresholds. This was particularly true for process schizophrenics but also occurred with reactive schizophrenics. N was equalized for all groups in computing the trend analyses.

RESULTS

Visual inspection of the data before analysis indicated that the mean scores on either dependent variable (verbal report or pupillary response) for reactive schizophrenics in comparison to normal subjects did not support the predictions made, that is, that reactive schizophrenics would report pain earlier than normals and would show heightened pupillary response. Therefore Duncan's Multiple Range test (Edwards, 1960) was used to detect differences between groups.

Sensory Thresholds (Verbal Response)

Warmth Detection Threshold (WDT)

The difference scores on skin temperature (expressed in logarithmic units) at which warmth was reported were submitted to a randomized groups design analysis of variance. The rank order of the mean difference scores for each group was as follows: Normals M=.3668; Process M=.3930; Nonschizophrenics M=.4205; Reactive M=.5525. Table 1 presents a summary of the analysis. The lack of significance of the between groups sum of squares for WDT (F=.8245, df 3 & 56) indicates that the groups did not differ in threshold judgments of warmth.

TABLE 1

Summary of analysis of variance of Warmth Detection Threshold (WDT)

Source of Variation	Sum of Squares	df	Mean Squares	F
Between groups	0.2987	3	0.0996	0.8245
Within groups	6.7673	56	0.1208	

Pain Threshold (PT)

The rank order of the mean difference scores on skin temperature at which subjects reported a sensation of pain was as follows: Normals M=.7843; Reactive M=.8259; Nonschizophrenic M=.8911; Process M=1.0108. Analysis of PT revealed that groups differed significantly in their threshold for pain ($F=3.87$, df 3 & 51, $p < .05$). The results are presented in Table 2.

TABLE 2

Summary of analysis of variance of Pain Threshold (PT)

Source of Variation	Sum of Squares	df	Mean Squares	F
Between groups	0.3621	3	0.1207	3.8686*
Within groups	1.5935	51	0.0312	

* $p < .05$

Examination of the raw data indicated that 4 process schizophrenics and 1 reactive schizophrenic failed to report PT. Duncan's Multiple Range test for unequal ns (Duncan, 1957) indicated significant differences between process schizophrenics and normals ($p < .01$) and between process and reactive schizophrenics ($p < .05$).

Pain Tolerance (PTO)

Table 3 presents the results for analysis of the data on pain tolerance. There were some subjects, particularly in the process group, who failed to report PTO (5 process and 1 reactive). The heat was increased for these subjects up to the stimulus maximum and temperature recordings taken at each step. Results for PTO were initially analyzed using only those subjects who reported this

threshold. The rank order of the mean difference scores on skin temperature for each group was as follows: Reactive M=.9186; Normals M=1.0028; Process M=1.0453; Nonschizophrenic M=1.0522. Results of the analysis of variance (F=2.73) very nearly meet the 5% level of significance (required F=2.79).

TABLE 3

Summary of analysis of variance of Pain Tolerance (PTO) and Adjusted PTO

Source of Variation	Sum of Squares	df	Mean Squares	F
Between groups	0.1775	3	0.0592	2.7281
Within groups	1.0861	50	0.0217	
		Adjusted PTO		
Between groups	0.2268	3	0.0756	2.853*
Within groups	1.4890	56	0.0265	

*p <.05

Analysis was then made of the PTO scores including these subjects who reached the stimulus maximum without reporting PTO. This is referred to as 'Adjusted PTO' in Table 3. The rank order of the adjusted mean difference scores was as follows: Normals M=1.0028; Reactive M=1.0129; Nonschizophrenic M=1.0522; Process M=1.1581. The between groups sum of squares is significant (F=2.85, df 3 &56, p <.05) indicating that groups differed significantly in their level of pain tolerance. Duncan's Multiple Range test revealed that the difference between process schizophrenics and normals and reactive schizophrenics was significant (p <.05).

Choosing only those subjects in each group with complete data, that is three thresholds reported, a trend analysis was completed to examine all threshold values in relation to each other and to the groups. The results are presented in Table 4.

TABLE 4

Summary of trend analysis of Threshold Means

Source of Variation	Sum Squares	df	Mean Squares	F
Groups	0.4505	3	0.1502	1.358
Error (a)	3.9811	36	0.1106	
Thresholds	7.7669	2	3.8835	91.81**
Groups x Thresholds	0.4183	6	0.0697	1.64
Error (b)	3.0445	72	0.0423	
Linear Components:				
Thresholds	7.2649	1	7.2649	171.75**
Groups x Thresholds	0.3445	3	0.1148	2.71
Quadratic Components:				
Thresholds	0.502	1	0.502	11.867**
Groups x Thresholds	0.074	3	0.0246	0.581
Error (b)	3.0445	72	0.0423	

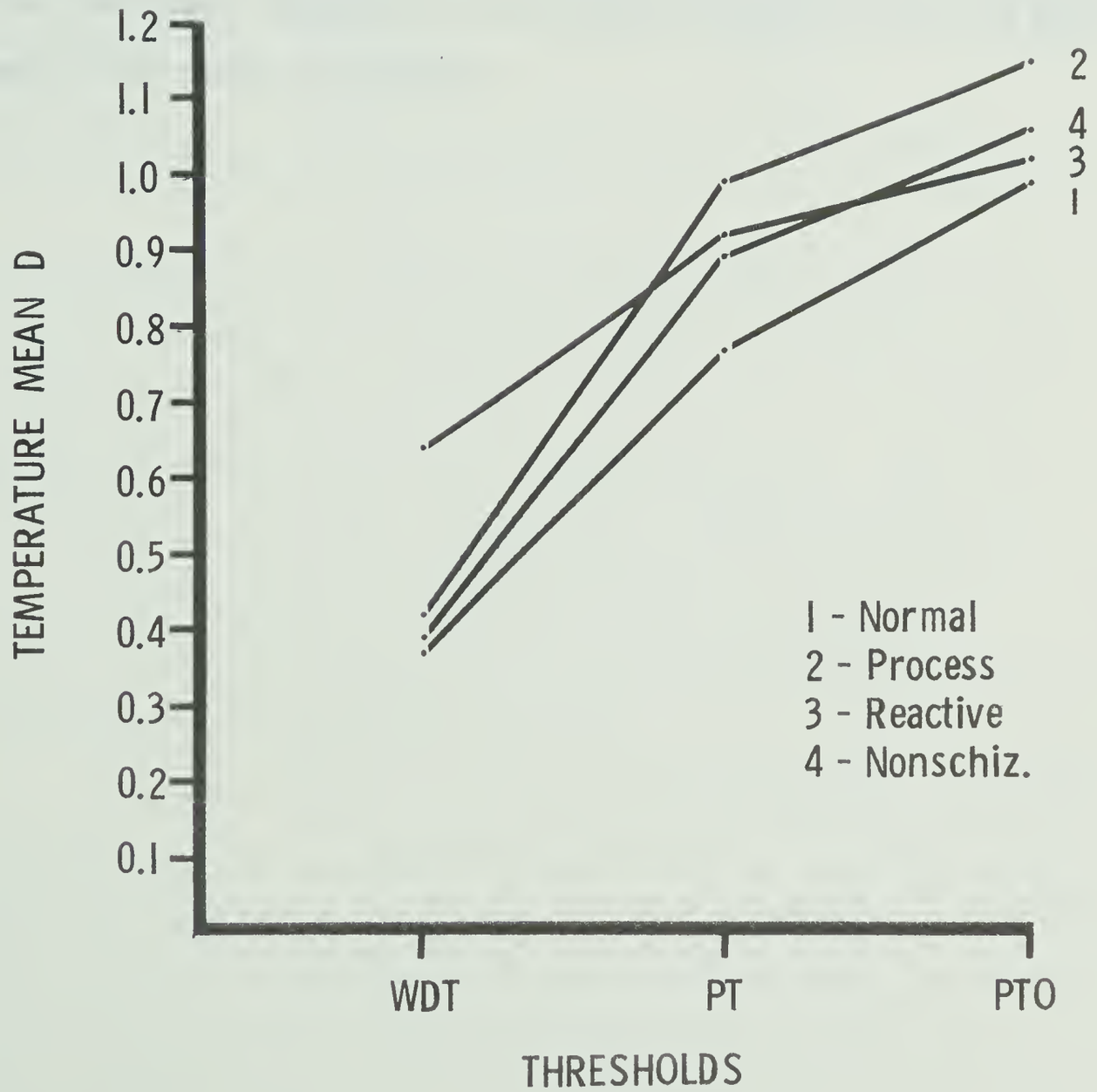
** $p < .01$

The significance of the threshold effect ($F=91.81$, df 2 & 72, $p < .01$) indicates that the threshold values averaged over subjects differ from each other. The lack of significance of the interaction ($F=1.64$, df 6 & 72) indicates that the trend of threshold means is of the same form for all groups. This can be verified by inspection of the plots of the threshold means (Figure 2).

Calculation of the linear component of the trend of the threshold mean reveals that these means show a monotonically increasing linear trend ($F=171.75$, df 1 & 72, $p < .01$). The lack of significance

FIGURE 2

SENSORY THRESHOLDS



of the linear component of the interaction ($F=2.71$, df 3 & 72) indicates that the differences between the groups do not change from one threshold to another.

Although the reliability of a quadratic component, based on 3 levels of a factor, is questionable, this component was calculated and the results are included in Table 4. The significance of the quadratic component of threshold means ($F=11.867$, df 1 & 72, $p < .01$) indicates that the trends deviate significantly from linearity. The lack of significance of the curvilinear component of the interaction indicated that the group trends do not differ in curvature.

Pupillary Response

Baseline Measures of Pupil Diameter

Baseline measures were submitted to a randomized groups design analysis of variance. Table 5 summarizes the results of this analysis.

TABLE 5

Summary of analysis of variance of baseline measures of pupil diameter

Source of Variation	Sum of Squares	df	Mean Squares	F
Between groups	19.7507	3	6.5836	10.8669**
Within groups	33.926	56	.6058	

**p <.01

The significance of the between groups sum of squares (F=10.8669, df 3 & 56, p <.01) indicates that differences exist between groups in their baseline measures of pupil diameter. The nature of this difference was analyzed by computing Duncan's Multiple Range Test. The rank order of the means for the groups was as follows: Normals M=5.33; Reactive M=4.72; Nonschizophrenic M=4.14, Process M=3.83. Duncan's test indicated that the differences between normals, nonschizophrenics, and process schizophrenics were significant (p <.05).

Pupillary responses were analyzed using difference scores which reflected the amount of pupillary dilation between the baseline measure and a particular point. Inspection of the data revealed that the rank order of means was identical for baseline measures (BASE), the maximum pupillary response (MAX) and the difference scores between these measures (D). The rank order in decreasing magnitude for each measure was as follows: Normals, Reactive Schizophrenic, Nonschizophrenic, Process szhizophrenic. Correlations were computed between the three

measures of pupillary response (BASE, MAX, and D) for each group and these correlations are presented in Appendix D. It is important to examine these correlations as they establish the validity of using difference scores for analysis of pupillary response. The critical correlations are those between D - BASE and D - MAX since significance of these would indicate that the results obtained using difference scores were artifactual. It can be seen that these correlations are insignificant for normal subjects and process schizophrenics, indicating that use of difference scores as a measure of pupillary response was a justifiable procedure. Correlations between D and BASE are significant for reactive schizophrenics ($p < .01$) and nonschizophrenics ($p < .05$), and the correlations between D and MAX are significant for reactive schizophrenics alone ($p < .05$). If the correlations had been significant for normal subjects, the results of this study obtained using difference scores could have been seriously questioned.

Pupillary Dilation in Relation to the Physical Stimulus (Heat)

The physical stimulus is here defined as amount of heat as measured by the temperature of the skin. To evaluate pupillary responses in relation to standard physical stimuli, subjects were selected whose skin temperature scores showed the same increments above the basal skin temperature. These increments which were the same for all the subjects were: 1.0, 5.0, and 10.0 degrees above their baseline values. These points were designated at T_1, T_2 and T_3 respectively. Pupillary dilation was recorded at each point and expressed as a difference score. Table 6 presents the mean difference scores for pupillary dilation at each point for all groups.

TABLE 6

Mean Difference Scores for Pupillary Dilation in Relation to the Physical Stimulus

	T_1	T_2	T_3
Normals	.25	.50	.50
Reactive	.03	.08	.23
Nonschizophrenic	0.0	.15	.12
Process	.10	.13	.16

Table 7 summarizes the results of the trend analysis completed on this data. The significance of the Temperature effect ($F=7.05$, df 2 & 72, $p < .01$) indicates that a relationship exists between amount of pupillary dilation and increases in the physical stimulus T_1, T_2, T_3.

There is also a significant effect between psychiatric groups and degree of pupillary dilation on an objective temperature scale ($F=5.51$, df 3 & 36, $p < .01$).

TABLE 7

Summary of trend analysis of Pupillary Dilation in Relation to the Physical Stimulus

Source of Variation	Sum of Squares	df	Mean Squares	F
Groups	2.0909	3	0.6970	5.51**
Error (a)	4.5550	36	0.1265	
Temperature	0.5792	2	0.2896	7.05**
Groups x Temperature	0.2388	6	0.0398	0.968
Error (b)	2.9620	72	0.0411	
Linear Components:				
Temperature	5.281	1	5.281	12.46**
Groups x Temperature	0.1064	3	0.0354	0.861
Quadratic Components:				
Temperature	0.051	1	0.051	1.241
Groups x Temperature	0.133	3	0.0443	1.078
Error (b)	2.9620	72	0.0411	

** $p < .01$

The lack of significance of the Groups x Temperature interaction ($F=0.968$, df 6 & 72) indicates that the trend of means of pupillary dilation scores is of the same form for all groups. This can be verified by inspection of Figure 3 which displays the mean difference scores of pupillary dilation in relation to the physical stimulus T_1, T_2, T_3 for each group.

Table 7 also includes the results for linear and quadratic components of the trend. The overall linear trend of means is significant ($F=12.46$, df 1 & 72, $p < .01$) indicating that the means for pupillary dilation show an upward linear trend. The quadratic components are statistically insignificant.

The difference in pupillary response between groups was analyzed separately for each level of the physical stimulus (T_1, T_2, T_3), using Duncan's Multiple Range test. The rank order of all means can be seen by referring to Table 6. At T_1 & T_2 the differences between normals and all groups were significant ($p < .05$). At T_3, the differences between normals, nonschisophrenics and process schizophrenics were significant ($p < .05$).

Pupillary Dilation in Relation to Sensory Thresholds

Table 8 presents the mean difference scores, indicating amount of pupillary dilation, for all groups at each threshold.

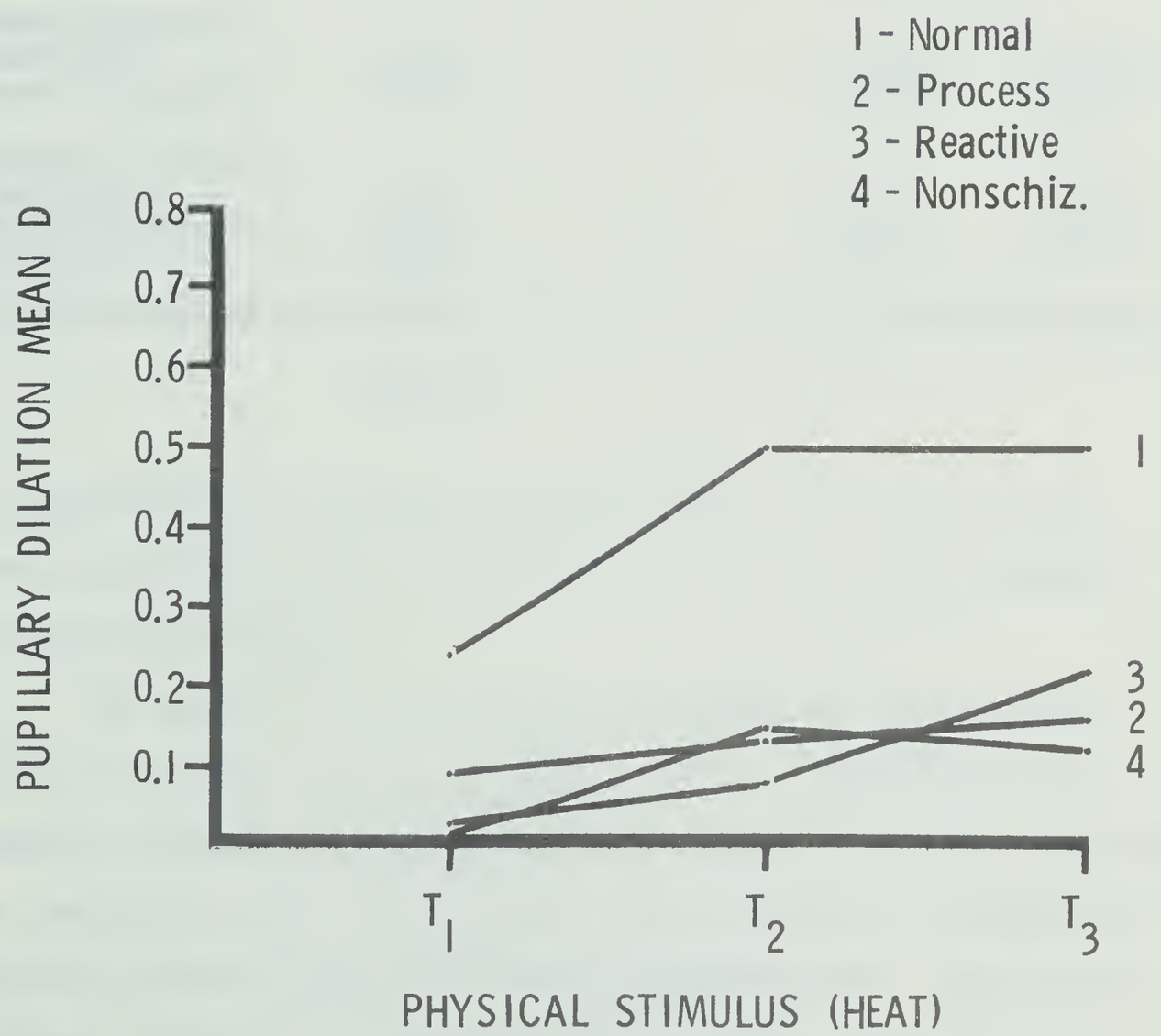
Table 8

Mean Difference Scores for Pupillary Dilation at Thresholds

	WDT	PT	PTO
Normals	.38	.57	.77
Reactive	.23	.47	.55
Nonschizophrenic	.14	.29	.48
Process	.04	.13	.10

FIGURE 3

PUPILLARY DILATION IN RELATION TO THE PHYSICAL STIMULUS



These difference scores were subjected to a trend analysis which is summarized in Table 9.

TABLE 9

Summary of trend analysis of
Pupillary Dilation in Relation to Sensory Thresholds

Source of Variation	Sum of Squares	df	Mean Squares	F
Groups	3.6789	3	1.2263	4.8037**
Error (a)	9.1924	36	0.2553	
Thresholds	1.5407	2	0.7703	29.97**
Groups x Thresholds	0.3713	6	0.0618	2.41*
Error (b)	1.8547	72	0.0257	
Linear Components:				
Thresholds	1.5125	1	1.5125	58.85**
Groups x Thresholds	0.3225	3	0.1075	4.18*
Quadratic Components:				
Thresholds	0.028	1	0.028	1.089
Groups x Thresholds	0.028	3	0.0093	0.361
Error (b)	1.8547	72	0.0257	

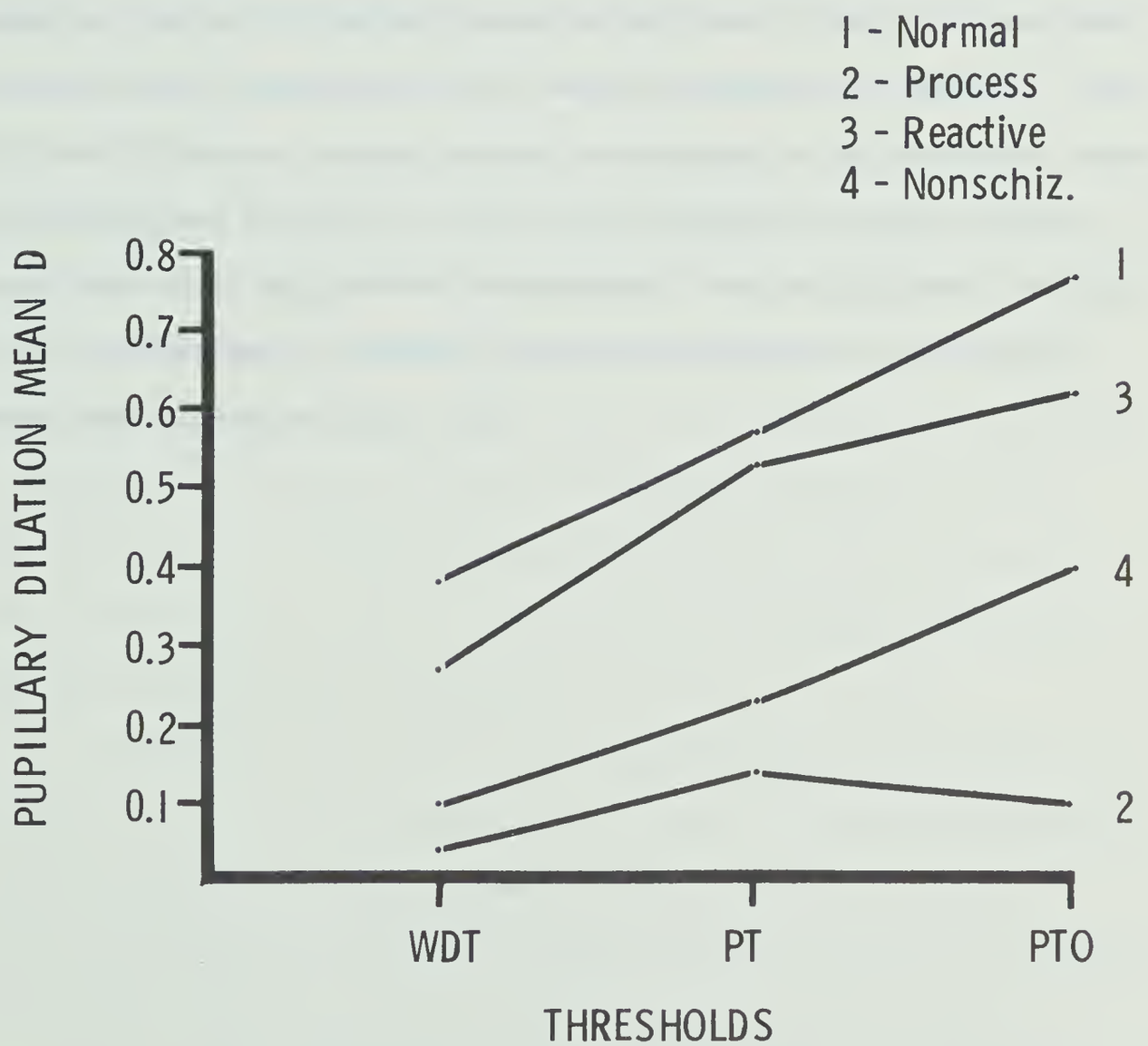
*$p < .05$
**$p < .01$

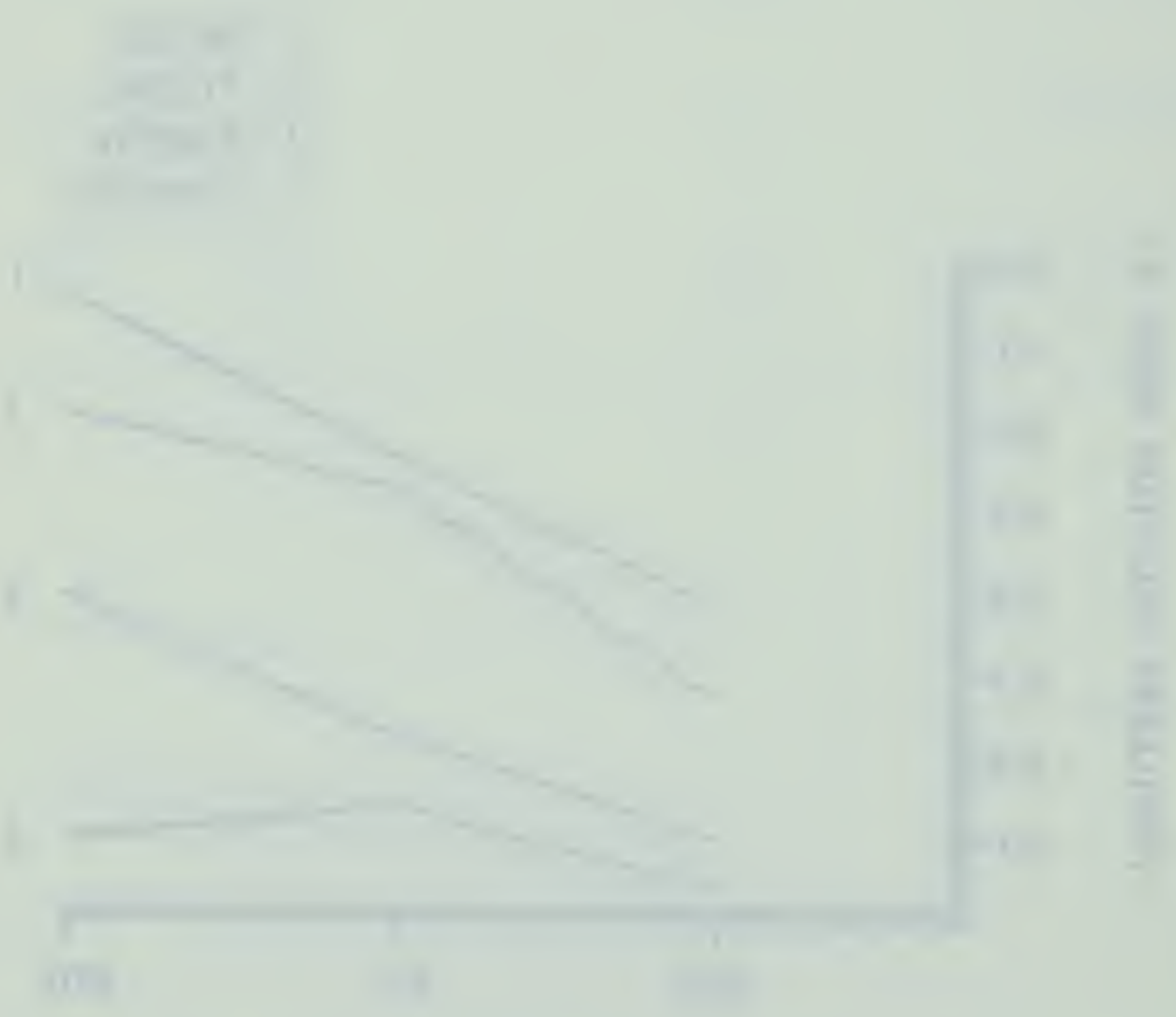
The significance of the Groups effect ($F=4.8037$, df 3 & 36, $p < .01$) shows that a relationship exists between amount of pupillary dilation and psychiatric diagnosis.

The results also indicate that a relationship exists between amount of pupillary dilation and verbal report of threshold, as the threshold effect is significant ($F = 29.97$, df 6 & 72, $p < .01$). Examining the interaction effect, it can be seen that the trend of the means for pupillary dilation differs significantly between groups. This can be verified by inspection of Figure 4 which displays the mean difference scores of pupillary dilation at each threshold for the different groups.

FIGURE 4

PUPILLARY DILATION IN RELATION TO SENSORY THRESHOLDS





Included in Table 9 are the calculations for linear and quadratic components of the trend. It can be seen that the means for pupillary dilation show a significant upward linear trend as indicated by the values for the linear component of threshold means ($F = 58.85$, df 1 & 72, $p < .01$). The significance of the linear component of the Groups X Threshold interaction ($F = 4.18$, df 3 & 72, $p < .05$) indicates that the slopes of the trends differ significantly between groups. The quadratic components were found to be insignificant.

The difference in pupillary response between groups was analyzed separately for each threshold report using Duncan's Multiple Range test. The rank order of all means can be seen by inspection of Table 8. At WDT, the differences between process schizophrenics and all other groups were significant ($p < .05$). At PT, the differences between normals, nonschizophrenics and process schizophrenics were significant ($p < .05$). At PTO the differences between process schizophrenics and all other groups were significant ($p < .05$).

Correlation Between Pupillary Response and Sensory Thresholds:

In an attempt to gain information regarding the relationship between the subject's subjective experience and report of pain and his autonomic or objective response to pain, pupillary response data were subjected to various correlation measures. Magnitude of pupillary response (MAG) and latency of this response (LAT) were determined for each threshold report and correlations were computed to determine the degree of relationship between these variables. The correlation matrices are presented in Appendix E. It can be seen that irrespective of threshold, MAG as a measure of pupillary response, appears to be more closely associated with threshold judgments than LAT. However, these correlations though significant, should be interpreted with caution. Examining the correlation matrices for the individual groups, it becomes apparent that the relationship between these response measures and threshold judgments is variable and in most cases insignificant.

As mentioned in the Introduction, it is important to establish an objective criterion to evaluate a subjective experience such as sensation of pain. Having chosen this criterion, some measure of association should be made to determine if the criterion is actually related to the perceptual experience.

It was predicted that reactive schizophrenics having low threshold values would in turn show the largest increments in pupillary dilation along the standard temperature scale T_1 - T_2 - T_3. Process schizophrenics having the highest threshold values would show the smallest increments in pupillary dilation along the standard temperature scale. Normal subjects were expected to resemble reactive schizophrenics in this analysis.

Appendix F presents the correlation matrices for each group. It appears that the most significant pupillary response, irrespective of groups, occurs between temperature values T_1 and T_2. The correlations for reactive schizophrenics are not in the expected direction, nor do they reach statistical significance. This finding corresponds with analysis of threshold reports which revealed that reactive schizophrenics did not report pain earlier than normal subjects. The correlations for normal subjects and process schizophrenics are in the expected direction, however, only one value reaches significance for normals. This indicates that the predicted relationship between threshold for pain and pupillary response may hold only for normal subjects.

Maximum Pupillary Respones and Percentage Change

The maximum pupillary response (MAX) occurring throughout the entire experimental session was determined and a graphical analysis was made to determine where this response occurred in relation to the threshold reports. It was anticipated that MAX would occur more frequently near PTO for normal subjects and nonschizophrenics, while MAX would occur more randomly in relation to threshold judgments (the frequency distribution would be more scattered) for process schizophrenics. This data is presented in Figures 5 and 6. It can be seen that MAX coincides more frequently with PTO for normals and nonschizophrenics than for the schizophrenic groups, indicating a linear relationship between increasing temperature and maximum pupillary response for these two groups.

FIGURE 5

FREQUENCY DISTRIBUTION OF MAX
IN RELATION TO SENSORY THRESHOLDS

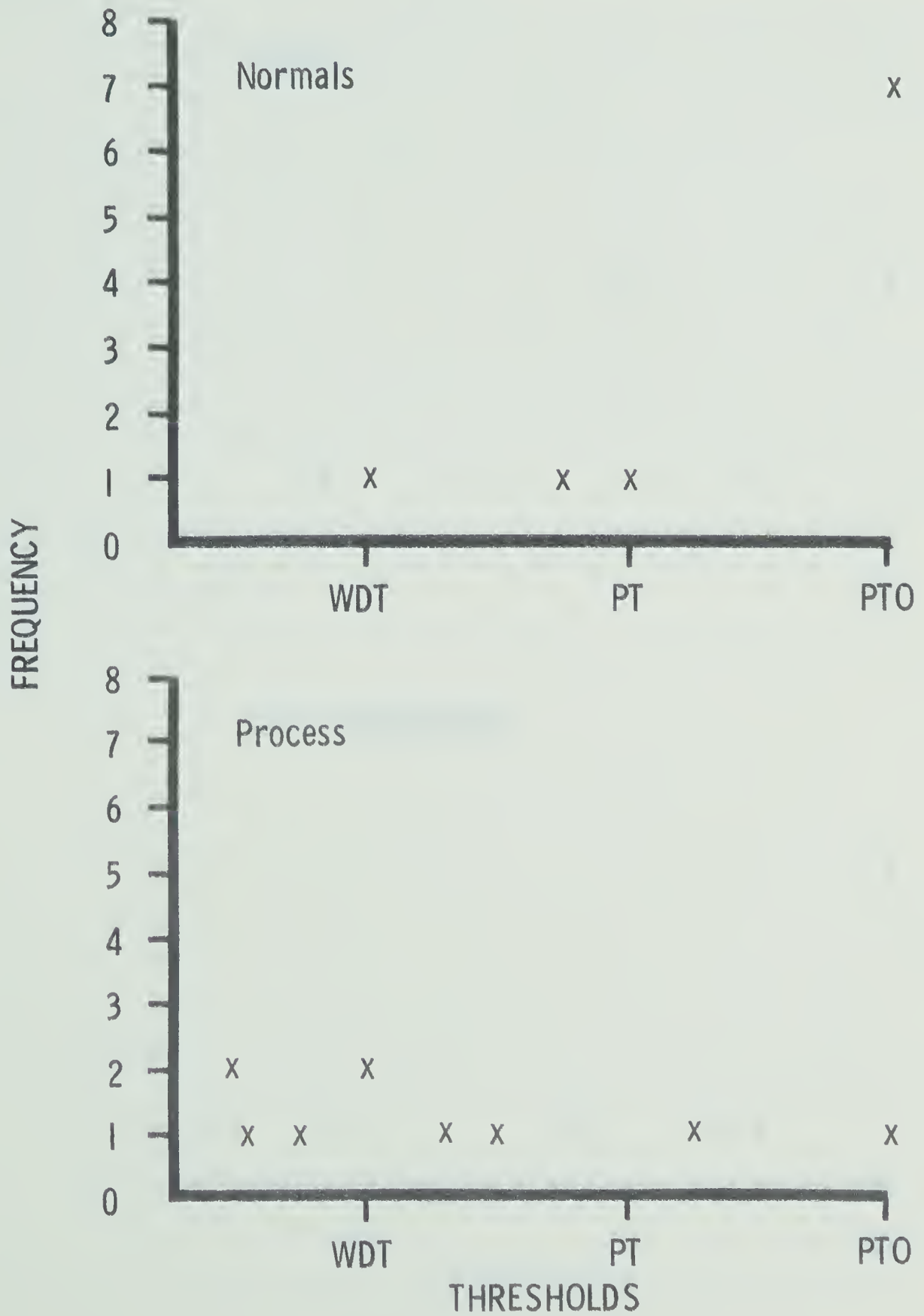
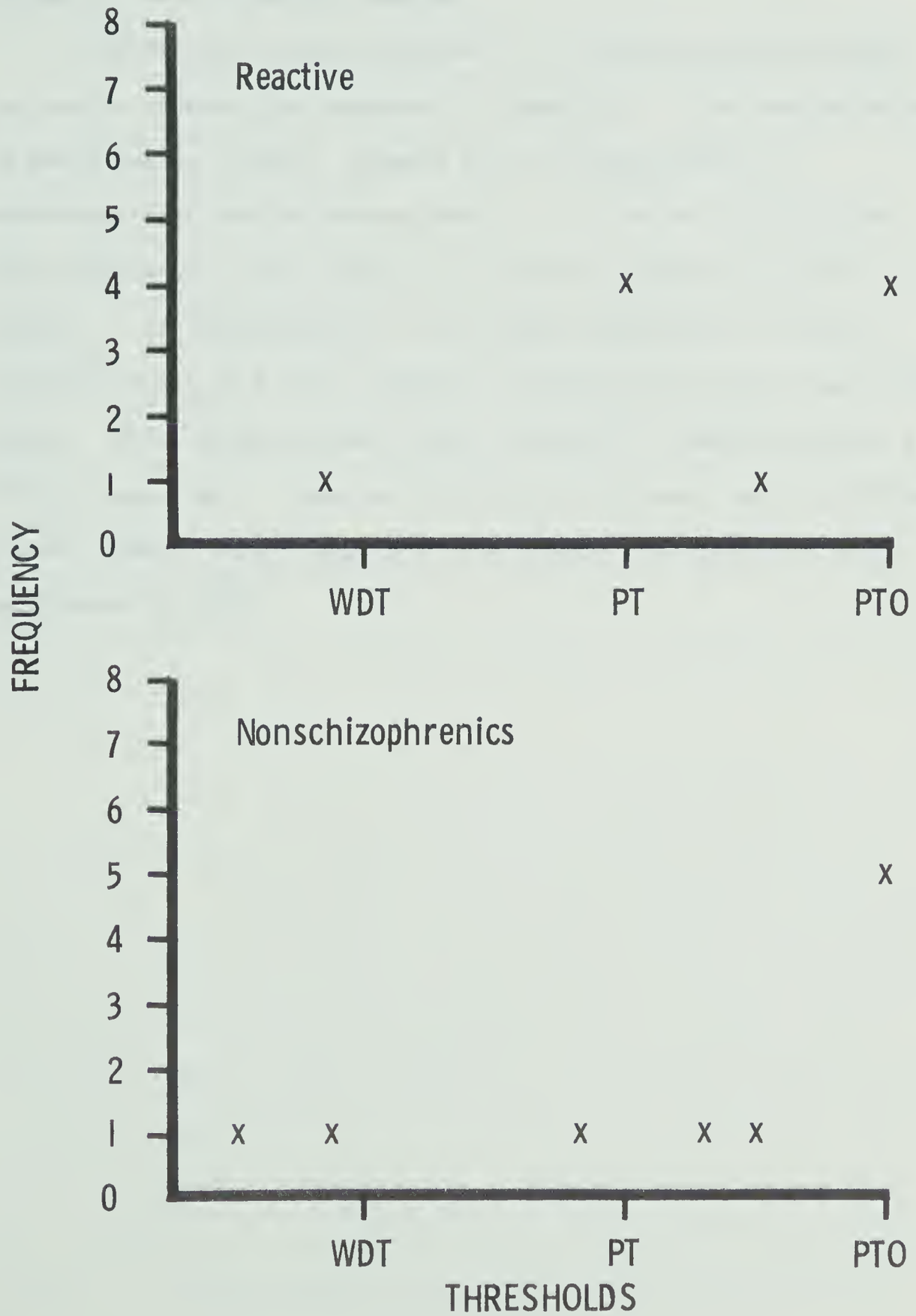


FIGURE 6

FREQUENCY DISTRIBUTION OF MAX
IN RELATION TO SENSORY THRESHOLDS



As initial differences between groups were found on baseline measures of pupil diameter, analysis was made of the maximum responses (MAX) to determine if these differences between groups were sustained throughout the experimental session.

The MAX scores were submitted to a randomized groups design, the results of which are presented in Appendix G. The rank order of the means was as follows: Normals M=6.01; Reactive M=5.18; Nonschizophrenic M=4.54; Process M=4.13. It can be seen that the rank order is the same for MAX as for Baseline measures of pupil diameter. The significance of the between groups sum of squares ($F=239.01$, df 3 & 56, $P < .01$) indicates that MAX was not the same for all groups. This difference was further analyzed by computing Duncan's Multiple Range test. Results of this test indicated that the differences between normals, nonschizophrenics and process schizophrenics were significant ($p < .05$).

DISCUSSION

Before evaluating the results obtained in this study, a criticism must be levied against the apparatus employed for producing radiant heat. The majority of published research on thermal stimulation is based on results obtained with the Hardy-Wolff Dolorimeter (Hardy, Wolff, and Goodell, 1952). It was not possible to purchase this equipment and therefore an alternative method of producing radiant heat was used. However, it was found that the light source in this apparatus could not be accurately calibrated and thus stimulus intensity could not be increased in standard units. Using skin temperature as a measure of stimulus (independent variable) was a justifiable procedure because the readings of the initial skin temperature indicated that the groups did not differ from one another. Also, although the skin temperature depends not only on the amount of radiant heat applied but also on the flow of blood, an argument can be made that it is a more appropriate measure of the actual stimulus acting on the nerve endings than the amount of heat as measured in calories.

Only the ascending series of heat increments was used because of the possible effect of suggestion on experimental pain found in a previous study. Using normal subjects, Wolff and Horland (1967) found significant differences between the measures on ascending and descending series of pain threshold under non-permissive instructions. The explanation offered by these authors was that pain, when severe, tended to produce an emotional state which could interfere with normal cognitive processes and sensory discrimination. Relief from pain, in the same manner could produce an emotional state which also interferes with such processes. Subjects demonstrated an elevated Pain Threshold on the

descending series possibly due to anticipation of relief from pain. In the present study differences between groups would have been very difficult to interpret on a descending series, as the majority of subjects could be described as exhibiting an already disordered emotional state.

It appears that the "process - reactive" dimension corresponds to the "acute - chronic" dimension, the latter dimension being defined by length of stay in hospital. Process schizophrenics differed significantly from reactive schizophrenics in length of hospitalization, and they could be described as the more chronic patients, while reactive schizophrenics could be described as the more acute patients. Although there are similarities between the two descriptive dimensions, the implication of progressive deterioration embodied in the "acute-chronic" dimension is not necessarily implicit in the "process-reactive" dimension. Ideally, length of hospitalization should have been controlled and the schizophrenic sample both "process and reactive" drawn from, for example, newly admitted patients.

Support was obtained for the validity of the Self-Report Scale (Ullmann and Giovannoni, 1964) in finding differences in sensory and physiological reactivity between process and reactive schizophrenics. As far as sensory thresholds were concerned, significant differences were found between reactive and process schizophrenics in PT and PTO. Also significant differences were obtained in the measures of pupil responsivity, both in relation to the physical stimulus and verbally reported pain sensation.

In general the hypothesis that process schizophrenics would exhibit a higher PT and PTO than normals was confirmed. These findings confirm results obtained by Hall and Stride (1954) who also obtained high thresholds of pain as reported verbally and as inferred from the

observed behavior of the patient. Differences between groups were not significant on report of WDT. Results for PTO indicate that when those subjects who failed to report PTO are included in the analysis, significant differences appear between the groups. Inspection of the raw data indicated that 4 process schizophrenics did not report PT and 3 from this group did not report PTO. One patient from the reactive group failed to report PT.

The hypothesis that reactive schizophrenics would evidence lower PT and PTO values than normal subjects was not confirmed. The means for both thresholds fell above those of normal subjects. These results suggest that reactive schizophrenics demonstrated reduced awareness of stimuli (as measured by verbal report of threshold) but to a lesser extent than process schizophrenics. The rank order of group means for PT and PTO indicated nevertheless that reactive schizophrenics were more similar to normal subjects in their threshold judgments than were nonschizophrenics and process schizophrenics. The dimension of "process-reactive" in terms of verbal report of sensory threshold represents a continuum of reduced responsivity to a noxious stimulus in comparison to normal responsivity.

At first glance it would appear that process schizophrenics, demonstrating higher tolerance for pain than the other groups could be characterised, following Petrie's (1967) theory of perceptual reactance, as "reducers". However, in order to justify the use of her concepts the position of <u>all subjects</u> along the "augmenter - reducer" dimension would have to be established by measuring Kinesthetic Figural Aftereffect. Nevertheless, one could theoretically predict that process schizophrenics would reduce the impact of sensory input as compared with normal responses to the same amount of stimulation.

The fact, (as indicated by an insignificant interaction effect) that differences between groups remained the same for verbal reports of sensory thresholds is unexpected in view of the findings of Ullmann and Krasner (1963). Experimental pain threshold and pain tolerance were thought by these authors to have different proportions of physiological and psychological reaction components. Pain threshold was to a greater degree determined by physiological (sensory processes) factors and pain tolerance to a greater degree by psychological (emotional responses) factors in normal subjects. As a result, in the present study it could be predicted that if there were no sensory abnormalities in process schizophrenics, deviations in response to pain as a result of abnormal mental state would appear largely on a psychological level that is, on measures of pain tolerance. However, the lack of significance of the interaction effect contradicted this prediction as the differences between the groups did not change from one threshold to another. In light of these results and also those of pupillary responses, high pain thresholds in process schizophrenics cannot be explained only by a disturbance in higher psychological processes, such as lack of attention and altered response bias. There is a possibility of an impairment of the physiological sensory mechanisms.

Interpretation of the differences between the groups in verbal reports of sensory thresholds are impossible without considering at the same time the results of pupillary responses to painful stimulation. The measure of verbally reported sensory thresholds may depend both on the subjective sensation and the response bias of the subject (Price, R.H. 1966). An involuntary physiological response, such as pupillary dilation to painful stimuli, would serve to indicate to what extent the obtained differences in verbal report are due to response bias. If the

differences were due only to response bias, process schizophrenics would be expected to have the same pupillary response at the same level of stimulus intensity as normal subjects, and a greater response at PT and PTO, reported at a higher level of the stimulus intensity than normals. It was found that process schizophrenics had significantly lower pupillary responses than the other groups at the same levels of intensity of the physical stimulus; and also that their pupillary responses were significantly lower at PT and PTO. Thus it seems that their higher sensory thresholds were due to a difference in sensory and perceptual processes rather than to a difference in response bias.

Pupillary response to the physical (external) noxious stimulus (heat, measured by skin temperature) measures the autonomic (sympathetic) reaction to that stimulus. The verbal response (threshold) measures the sensory reaction to the same stimulus. The problem is: Do these two responses coincide and if so, to what degree in different groups? This general problem can be tackled by answering more specific questions. The first question is the following one: Is there a correlation between magnitude of pupillary response at certain standard temperatures and the different thresholds? If so, the validity of using verbal reports as indicative of pain thresholds is to a certain extent established. The correlations obtained (Appendix F), although in the predicted direction for normals and process schizophrenics, fell below the required level of significance apart from one value for normal subjects. One explanation for the insignificant correlations for the process schizophrenics is that T_3, representing an increase of 10.0 degrees above the initial skin temperatures, fell considerably below the mean skin temperature at which this group reported PTO. The mean initial skin temperature for normals was 91.83 degrees and 10.0 degrees above this (101.83) represents an

average value for T_3 which is very close to the mean skin temperature at which they reported PTO (102.63 degrees). In contrast, the mean initial skin temperature for process schizophrenics was 92.63 degrees and 10.0 degrees above this (102.63) represents an average value for T_3 which falls below the mean skin temperature at which this group reported PTO (107.3 degrees). The second question to be answered is: Are there corresponding differences in the pupillary responses of various groups and their verbal responses to the physical stimulus (heat)? If so, there are differences in both sensory (psychological) and physiological responses. The results indicate that process schizophrenics have lower responsivity than all the other groups to noxious (heat) stimuli, when this responsivity is measured either by their sensory thresholds or by their pupillary (physiological) responses.

The third specific question is: Do the groups differ in the amount of physiological (autonomic) response at the same level of sensory response? This is measured by the differences of pupillary response in different groups at the different thresholds. If these differences are significant, it would mean that there is some dissociation between the sensory (psychological) response and the autonomic (affective) response in schizophrenics. Significant differences were found in pupillary responses accompanying verbal reports of subjective pain sensation at both PT and PTO. There was a significant interaction between these levels and the groups, thus indicating that the differences between the groups at PT and PTO levels were not the same.

Examining separately the differences between groups for each threshold, it was found that the prediction of a greater pupillary response for reactive schizophrenics as compared to normals could not

be confirmed. The differences in pupillary reactions were in the opposite direction from that which was predicted. For each threshold the means for reactive schizophrenics ranked below those of normals, but the differences were statistically insignificant. As was predicted, the differences between normals and nonschizophrenics in pupillary response were not significant except for the measures taken at PT, which demonstrated reduced pupillary responsivity for nonschizophrenics as compared with normals.

Reduced pupillary responsivity in relation to sensory threshold was consistently demonstrated by process schizophrenics. A noxious stimulus, although producing a pain sensation at a certain level of its intensity, produces less arousal and affective response in process schizophrenics than in the other groups. This group differed consistently from all other groups in their physiological response at the different sensory thresholds, whereas reactive schizophrenics did not differ from normal subjects in their autonomic responses at the same level of sensory response.

Diminished pupillary responsivity demonstrated by process schizophrenics in comparison to normals corroborates the results reported by Streltsova (1955) on a group of mixed schizophrenics. The vast majority of her patients showed no pupillary response or else greatly reduced reactivity to hot and cold tactile stimuli, an odor and a bell. A very few subjects showed abnormally large dilation, a response which according to Streltsova, never occurs in normal subjects. She argues that the low reactivity of the majority of her schizophrenics is a result of high levels of protective inhibition producing low sympathetic tone and reactivity. The use of heterogenous samples makes the interpretation of Streltsova's findings difficult.

Pavlov, in his formulation of protective inhibition, believes that the nervous system is capable of reducing the impact of excessive stimulation. When a nerve is subjected to excessive stimulation it will stop transmitting impulses so as to avoid permanent damage. Russian researchers have hypothesized that the majority of schizophrenics are characterized by higher levels of protective inhibition than normal individuals (Lynn, 1968). Since high levels of protective inhibition reduce neural transmission, and since all forms of mental activity depend on neural transmission, the schizophrenic's higher level of protective inhibition can be used to explain the fact that they react differently than normals. Russian research workers interpreting their data within a Pavlovian framework have arrived at the same conclusions as several researchers in the West.

In the present study the sympathetic or adrenergic mechanism alone was examined in response to stress. The means for pupillary dilation at thresholds for process schizophrenics were significantly lower than for normal subjects. The means for pupillary dilation in relation to the two lowest levels of the physical stimulus (T_1 and T_2) for all psychiatric groups were significantly lower than for normal subjects. Using Rubin's framework we could interpret this as indicative of decreased sympathetic activity in response to stress. Process schizophrenics exhibited the greatest deviation from normals in this respect. It is interesting however, that all psychiatric patients exhibited a disordered autonomic response to stress, even those not considered schizophrenic. One might have expected the nonschizophrenic group to respond like normals. The findings suggest that, for this group, some other variable is operating producing low sympathetic reactivity. Before concluding that the nonschizophrenic sample could be

characterized by defective autonomic responsivity, one would have to rule out such factors as drug effect and institutionalization. Although medications for all patients were discontinued three days prior to testing, there may have been some residual drug effects which influenced the results obtained from this group.

Examining more closely the results of the nonschizophrenic patients, it can be seen that on measures of verbally reported sensory thresholds (PT and PTO) this group did not differ significantly from process schizophrenics. However, on measures of pupillary responsivity both in relation to the physical stimulus (heat) and to the sensory thresholds, nonschizophrenics evidenced significantly higher levels of responsivity to noxious stimulation than process schizophrenics.

Comparing the results of the nonschizophrenic patients with those of normal subjects, it can be seen that nonschizophrenics reported PT and PTO at a significantly higher level than normal subjects. Also this group demonstrated significantly reduced pupillary (sympathetic) reactivity in relation to the physical stimulus and in relation to their verbal report of pain threshold (PT).

These findings would argue against distinguishing schizophrenia as a disease entity in accordance with the Kraeplinian tradition. They argue for regarding normals and psychiatric patients as lying on the same continuum with the biological adaptive mechanisms (pupillary responsivity) being most effective in normals and least effective in process schizophrenics. This "level of effectiveness" in a biological sense could be related to "level of adjustment" in a psychological sense which could be defined in terms of length of stay in hospital. Reactive schizophrenics as a group were hospitalized for the shortest period of time and process schizophrenics for the longest period, with nonschizoph-

renics falling between these two groups. Subjects could then be ranked according to "level of adjustment" in the following order: Normals (highest level of adjustment), Reactive schizophrenics, Nonschizophrenics, and Process schizophrenics (lowest level of adjustment).

Impaired sympathetic reactivity as measured by the mecholyl test has been demonstrated in chronic schizophrenics (Weckowicz, 1958) and provides additional evidence for Rubin's hypothesis. The comparison however, cannot be directly made with results of the present study due to differences in classification used. More generally, numerous studies of reactivity to stimulation reveal a diminished ANS response in chronic schizophrenia. Stressors that have yielded hyporeactivity include inhalation of heated air (Freeman and Rodnick, 1940) and cold baths (Buck, Carscallen & Hobbs, 1950). Schizophrenics show reduced rotational and caloric nystagmus (Angyal & Blackman, 1940; Freeman & Rodnick, 1942; Leach, 1950) and reduced GSR responses have been noted (Hock, Kubis & Rouke, 1944).

Hyporeactivity in chronic patients however, may be partly a function of their higher basal levels rather than simply evidence of sluggish responsiveness. The "law of initial values" (Lacey, 1956) accounts for reduced responsivity when organisms approach homeostatic limits. Williams (1953) and Malmo, Shagass and Davis (1951) show that resting rates in chronic schizophrenic patients tend to be higher than those of acutes, especially in skin conductance and heart rate. Reactivity is often less in chronic than acute schizophrenics, and lower in process than reactive patients. Malmo & Shagass (1949) reported that early schizophrenics are hyperreactive and resemble anxiety neurotics in EMG response to pain. Chronic patients showed a reduced muscular response to a painful stimulus. These results evidencing

hyporeactivity have often been interpreted in conjunction with studies showing high resting levels of sympathetic activity in chronic schizophrenics. According to "activation" theory (Malmo, 1958; Lacey, 1956) responsivity progressively decreases when plotted on an abscissa of increasing activation, defined by base activity level. Chronic schizophrenics are assumed, by many researchers, to be in a continual state of high arousal, which causes low reactivity of the sympathetic nervous system. However, in the present study it was found that the process schizophrenics had significantly smaller pupillary diameters than the other groups at the beginning of the experiment. This finding would suggest that their basal level of arousal was lower instead of being higher, than the level of arousal in the other groups.

It is not certain whether, in the present study, the baseline determination of pupil diameter actually represents a true resting basal level. The measurements were made during the first stimulus presentation, which was of a very low intensity and was not considered physiologically stressful. This procedure overlooked the fact that being a subject in an experiment might have been psychologically stressful to the individual, irrespective of whether he received a noxious stimulus or not. Pupillary changes are known to occur in response to emotional factors such as fear, anxiety, startle (Lowenstein & Loewenfeld, 1950). Analysis of the differences in baseline measures of pupil diameter revealed that process schizophrenics evidenced the smallest diameter, normal subjects the largest diameter, with reactive schizophrenics and nonschizophrenics falling midway between these two extremes. It might be speculated that psychologically, process schizophrenics did not interpret the experimental situation as threatening in the same manner as the other groups and therefore, these patients did not exhibit pupillary changes. More reliable basal measure could have

been obtained after letting the subject habituate to the experimental situation for a certain length of time. If the reliability of the measure of basal pupillary diameter is accepted, the obtained relations between the initial pupillary diameter and the amount of pupillary response are opposite to that postulated by the activation theorists.

We must now evaluate the results obtained with reference to sensory thresholds. To account for the finding that a group of psychiatric patients evidenced higher thresholds for pain than normal subjects, one could formulate a number of explanations. These explanations will now be discussed.

One might argue that high threshold for pain is due to insensitivity of peripheral sensory organs, which would interfere with transmission of neural impulses to higher centers. However, there is no physiological evidence to support this theory.

Some theorists might advocate that schizophrenics experience the sensation of pain but they do not communicate this experience. The breakdown is considered to be on a psychological level. Proponents of Signal Detection theory would suggest that differences in sensory thresholds could be explained on the basis of response bias, that is different groups respond according to different standards. Hall and Stride (1954), finding variation in pain tolerance in psychiatric disorders, interpreted this as indicative of difference in pain conceptualization or "central attitude". These factors were felt to influence verbal and motor responses to painful stimuli. The suggestion was even made that unresponsive subjects may be fulfilling "masochistic tendencies to feel pleasure, i.e., reward in being hurt". No one could definately say whether schizophrenics are motivated by masochistic needs but the results of the present study suggest that it is not central attitude or conceptualization of pain

alone which accounts for unresponsiveness of the schizophrenic sample to painful stimulation. Had this been the case, we would have found no differences between schizophrenics and normals in pupillary response or sympathetic reactivity to pain. Hall and Stride (1954) may be correct in arguing that the interpretation of the pain stimulus, instructions and experimental situation by schizophrenics is different from the experimenter's interpretation. Nevertheless, this factor cannot be used as the sole explanatory principle.

Mental set may be defined as the process of being prepared to respond to an expected stimulus and being selectively attentive to certain classes of stimuli or aspects of stimuli.

The maintenance of mental set requires adequate attention mechanisms. A host of studies indicate set disturbance in schizophrenia (Shakow, 1962; Rodnick & Shakow, 1940; King, 1961; Tizard & Venables, 1967). On the one hand, schizophrenics are unable to maintain response readiness, and response latency increases if stimuli are presented in more than one modality. On the other hand, these patients seem unduly influenced by a previous set, and responses persist long after they are demonstrably ineffective. Disturbances of set in schizophrenia may be interpreted in terms of learned behavior. From this point of view, the schizophrenic is a predictable product of an environment which has provided little reinforcement when the individual reacted to it. The schizophrenic learns ultimately to ignore an environment where stimuli do not represent consistent reinforcement.

Subjects instructed to report certain features of sensation, such as perception of pain, must attend to the impinging stimulus and maintain this set. If one ignored the results of pupillary response to stimulation in this study, elevated thresholds for pain exhibited

particularly by process schizophrenics could be interpreted as due to disturbances in mental set, where these subjects have learned not to attend to impinging stimuli. However disturbances exist in sympathetic reactivity to the painful stimulus and this cannot be explained by the foregoing interpretation.

"Interference" theory also explains disturbances in mental set and appears as a more suitable construct in view of the results of this study. Shakow (1962) in summarizing his reaction time studies, crystallizes this theoretical viewpoint.

> Here we see particularly the various difficulties created by context, the degree to which the schizophrenic is affected by irrelevant aspects of the stimulus surroundings-- inner and outer-- which prevent his focusing on the "to-be-responded-to" stimulus.
>
> It is as if, in the scanning process which takes place before the response to a stimulus is made, the schizophrenic is unable to select out the material relevant for optimal response. He apparently cannot free himself from the irrelevant among the numerous possibilities available for choice. In other words, that function which is of equal importance as the response to stimuli, namely, the protection against the response to stimuli, is abeyant (p.25).

Buss and Lang (1965) consider interference theory to be clearly supported by the data on schizophrenic deficit, and to point to a fundamental sensorimotor defect in schizophrenia.

Failure to report pain, along with disturbance in sympathetic reactivity to the stimulus can be seen as a failure of the scanning mechanism, although the site for this disturbance cannot be determined. The defect here was seen most clearly in the response behavior of the process schizophrenics, while acute schizophrenics and nonschizophrenics exhibited this to a lesser extent. In a sudden emergency the organism must mobilize and selectively focus on specific aspects of the environment to reduce the threat, psychological or biological. The sympathetic

nervous system is involved, as we have already seen, in alerting the organism. If this alerting mechanism is disrupted, the stressful event, when added to an already excessive amount of impinging stimuli, is likely lost in the flood of information.

Selectivity theory put forward by Weckowicz and Blewett (1959) is very similar to Interference theory and could also be employed to explain the present results. These authors suggest a possible site of disturbance, the reticular activating system, a system which acts as a filtering mechanism in the neurophysiological makeup of the human. Some defect in the mechanism allows irrelevant, excessive information to pass to the cortex, making selective attention, maintenance of set, next to impossible for the schizophrenic. The organism is prevented from attending to a biologically significant stimulus.

Although it is not the purpose of this study to identify or locate a site in the central nervous system which may be malfunctioning in schizophrenics, and thus responsible for disorders in pain response, a neurological model can be offered as a tentative explanation of the findings. Melzack and Wall (1965) formulate a "gate control" theory of pain which is useful in understanding the complexity of the pain response and its relationship to schizophrenia. These authors propose that the substantia gelatinosa operates as a "gate control system" which modulates afferent input before it reaches the first central transmission cell (T cells) in the dorsal horn. The signal which triggers the "action system" (the system which they consider to be responsible for pain perception and response) occurs when the output of the T cells reaches or exceeds a certain level. This critical level of firing is determined by the afferent barrage impinging on the T cells, which has already been modulated by activity in the substantia gelatinosa.

This modulation takes the form of positive and/or negative feedback mechanisms which influence the afferent transmission to the T cells. A mechanism, the "central control trigger" is postulated which activates central brain processes subserving attention, emotion, and past experiences and this mechanism is seen as exerting control over afferent sensory input as well.

It is tempting to suggest that some neurological impairment exists in schizophrenia such that the "gate control system" does not produce the necessary balance between positive and negative feedback to ensure selective firing of the T cells. Evidence suggesting high levels of spontaneous background physiological activity in schizophrenics (Buss and Lang, 1965) would suggest that the gate system is wide open and the selective firing of cells is rendered impossible.

Silverman's (1967) formulation of "sensory input processing--ideational gating", describing an information processing mechanism is a pertinent consideration at this point. This principle applies essentially to nonparanoid and process types of schizophrenics.

> " It is based upon neurophysiological studies and concept formation studies which indicate that in these schizophrenic types: (1) reactivity to sensory attributes of stimulus configurations is unusually strong, (2) attentiveness to perceptual-ideational attributes of stimulus configurations is thereby reduced, (consequently, thinking is "stimulus-bound" or concrete), and (3) under conditions of stress, the action of this gating mechanism is exaggerated and perceptual ideational attributes of threatening environmental stimuli are excluded from awareness." (p.240)

Distinction is drawn between active attention, connoting acts of search and selection of certain stimuli along with inhibition of response to all other stimuli, and passive attention wherein the individual is directed by aspects of external environment and is captured (in a nonvolitional sense) by these stimuli. Active attention is typically

impaired in nonparanoid and process schizophrenia (Rapaport, 1951).

Performance of process schizophrenics in response to painful stimulation could be described as a negation of the biological or psychological significance of the stimulus, that is, as stressful. Because of impairment in active attention, there is a dominance of sensory events, which excludes biological or psychological responses which would reduce the impact of the painful stimuli. That is, the process schizophrenic is not able to indicate appropriately, his experience of pain, either by saying "I feel pain," or by employing a physiological response mechanism such as pupillary response. To a lesser extent this impairment is exhibited by reactive schizophrenics and nonschizophrenic patients.

CONCLUSION

Process schizophrenics evidenced reduced sensory response (verbal report of sensory thresholds) as well as reduced physiological response (pupillary dilation) to noxious stimulation as compared with all other groups. Impaired pain response appears on both a conscious (psychological) level and a biological (sympathetic nervous system). level.

Reactive schizophrenics resembled normal subjects in their responses to noxious stimulation. This group demonstrated reduced responsiveness in both their sensory responses and their physiological responses, but the differences (when compared with normal subjects) failed to reach statistical significance. This finding suggests that normal subjects and nonschizophrenic patients should have completed the Self-Report Scale for differentiating the "process-reactive" dimension. It may just be that this dimension represents a continuum of life adjustment along which any individual could be located.

Although conclusions regarding the results obtained from the sample of nonschizophrenic psychiatric patients are difficult due to diagnostic differences within the sample, it appears that this group ranked between process and reactive schizophrenics in their level of response, both in verbal report of sensory threshold and in pupillary response. This would suggest that nonschizophrenic psychiatric patients may represent some mid-point between the other psychiatric groups sampled along the above-mentioned dimension of life adjustment. However, more adequate control of the effects of medication and the length of hospitalization for all groups would have been necessary before such conclusions could be drawn.

References

Angyal, A. & Blackman, N. Vestibular reactivity in schizophrenia. Archives of Neurology and Psychiatry, 1940, 44, 611-620.

Becker, W.C. The process-reactive distinction: A key to the problem of schizophrenia? Journal of Nervous and Mental Disease, 1959, 129, 442-449.

Bender, W.R.G. The effect of pain and emotional stimuli and alcohol upon pupillary reflex activity. Psychological Monographs, 1933, 44, 1-32.

Bleuler, E. Dementia Praecox, or the group of schizophrenias. Leipzig Deutsche, 1911. English translation, New York: International University Press, 1950.

Buck, C.W., Carscallen, H.B. & Hobbs, G.E. Temperature regulation in schizophrenia: I. Comparison of schizophrenic and normal subjects. II. Analysis by duration of psychosis. Archives of Neurology and Psychiatry, 1950, 64, 828-842.

Buss, A.H. & Lang, P.J. Psychological deficit in schizophrenia: I. Affect, reinforcement, and concept attainment. Journal of Abnormal Psychology, 1965, 70, 2-24.

Buss, A.H. & Lang P.J. Psychological deficit in schizophrenia, II Interference & activation. Journal of Abnormal Psychology 1965, 70, 77-106.

Chapman, W.P. & Jones, C.M. Variations in cutaneous and visceral pain sensitivity in normal subjects. Journal of Clinical Investigation, 1944, 23, 81.

Clausen J. & King, H.E. Determination of pain threshold in untrained subjects. Journal of Psychology, 1950, 30, 297-305.

Duncan, D.B. Multiple range tests for correlated and heteroscedatic means. Biometrics, 1957, 13, 164-176.

Edwards, A.L. Experimental design in psychological research. New York: Holt, Rinehart & Winston, 1963.

Freeman, H., & Rodnick, E.H. Autonomic and respiratory responses of schizophrenics and normal subjects to change of intrapulmonary atmosphere. Psychosomatic Medicine, 1940, 2, 101-109.

Freeman H., & Rodnick, E.H. Effect of rotation on postural steadiness in normal and schizophrenic subjects. Archives of Neurology and Psychiatry, 1942, 48, 47-53.

Gebhard, J.W. Vision. Annual Review of Psychology, 10, 371-394.

Gelfrand, S. The relationship of experimental pain tolerance to pain threshold. Canadian Journal of Psychology, 1964, 18, 36-42.

Gelfrand, S., Ullmann, L.P. & Krasner, L. The placebo response: An experimental approach. Journal of Nervous and Mental Disease, 1963, 136, 379-387.

Glaser, S.Z. & Zenhausen, R. Short term sensory curtailment and sensory thresholds. Psychology, 1967, 4, 3-9.

Goldfarb, Wm. Pain reactions in a group of institutionalized schizophrenic children. American Journal of Orthopsychiatry, 1958, 28, 777-785.

Hall, K.R.L. Studies of cutaneous pain: a survey of research since 1940. British Journal of Psychology, 1953, 44, 279-294.

Hall, K.R.L., & Stride, E. The varying responses to pain in psychiatric disorders: a study in abnormal psychology. British Journal of Medical Psychology, 1954, 27, 48-60.

Hardy, J.D., Wolff, H.G., & Goodell, H. Pain Sensations and Reactions. Baltimore: Williams and Wilkins Co., 1952.

Hardy, J.D., Wolff, H.G., & Goodell, H. Studies on pain: A new method for measuring pain threshold: Observation of spatial summation of pain. Journal of Clinical Investigation, 1940, 19, 649-657.

Higgins, J. Concept of process-reactive schizophrenia: criterion and related research. Journal of Nervous and Mental Disease, 1964, 138, 9-25.

Higgins, J. & Peterson, J.C. Concept of Process-Reactive Schizophrenia: A critique. Psychological Bulletin 1966, 66, 201-206

Hock, P., Kubis, J.F., & Rouke, F.L. Psychogalvanometric investigations in psychoses and other abnormal mental states. Psychosomatic Medicine, 1944, 6, 237-243.

Hoffer, A., & Osmond H. The Hallucinogens. New York: Academic Press, 1967.

Huston, P.E. Sensory threshold to direct current stimulation in schizophrenic and normal subjects. Archives of Neurology & Psychiatry, 1934, 31, 590-596.

Johnson, M.H., & Ries, H.A. Validational study of the self-report scale for process-reactive schizophrenia. Journal of Consulting Psychology, 1967, 31, 321-322.

King, H.E. Some explorations in psycho-motility. Psychiatric Research Reports, 1961, 14, 62-86.

Kumnick, L.S. A scanning pupillometer. American Journal of Orthopsychiatry, 1959, 48, 259-262.

Lacey, J.I. The evaluation of autonomic responses: toward a general solution. Annals of the New York Academy of Science, 1956, 67, 123-164.

Leach, W.W. Nystagmus: An integrative neural deficit in schizophrenia Journal of Abnormal and Social Psychology, 1960, 60, 305-309.

Lemkau, P. V., & Crocetti, G.M. Vital statistics of schizophrenia. In L. Bellak (Ed.), Schizophrenia: a review of the syndrome. New York: Logos, 1958.

Lowenstein, O., & Friedman, E.D. Pupillographic studies: I. The present state of pupillography; its method and diagnostic significance. Archives of Ophthalmology, Chicago, 1942, 27, 969-993.

Lowenstein, O., & Loewenfeld, I.E. Role of sympathetic and para-sympathetic systems in reflex diation of the pupil. Archives of Neurology and Psychiatry, 1950, 64, 313-340.

Lynn, R., Russian theory and research on schizophrenia. Psychological Bulletin 1963, 60, 486-498.

Lynn, R., & Eysenck, H.J. Tolerance for pain, extraversion and neuroticism. Perceptual and Motor Skills, 1961, 12, 161-162.

Mack,D. Pain: Physiological or psychological? Papers in Psychology, 1967, 1, 22-25.

Maher, B.A. Principles of Psychopathology. New York: McGraw-Hill, Inc., 1966.

Malmo, R.B. Measurement of drive: an unsolved problem in psychology. In M.R. Jones (Ed.) Nebraska Symposium on Motivation. Lincoln: University of Nebraska Press, 1958, pp.44-105.

Malmo, R.B. & Shagass, C. Physiological studies of reaction to stress in anxiety states and early schizophrenia. Psychosomatic Medicine, 1949, 11, 9-24.

Malmo, R.B., & Shagass, C. Studies of blood pressure in psychiatric patients under stress. Psychosomatic Medicine, 1952,14, 82-93.

Malmo, R.B., Shagass, C., & Davis, J.F. Electromyographic studies of muscular tension in psychiatric patients under stress. Journal of Clinical and Experimental Psychopathology, 1951, 12, 45-66.

Malmo, R.B., Shagass, C., Davis, J.F. Cleghorn, R.A. Graham, B.F., & Goodman, A.J. Standardized pain stimulation as controlled stress in physiological studies of psychoneurosis. Science, 1948, 108, 509-511.

Malmo, R.B., Shagass, C., & Smith, A.A. Responsiveness in chronic schizophrenia. Journal of Personality, 1951, 19, 359-375.

May, P.R. Pupillary abnormalities in schizophrenia and during muscular effort. Journal of Mental Science, 1948, 94, 89-98.

McDonough, J.M. Critical flicker frequency and the spiral after effect with process and reactive schizophrenics. Journal of Consulting Psychology, 1960, 24, 150-155.

Melzack, R. & Wall P.D., Pain mechanisms: A new theory, Science, 1965 150 971-979.

Meyer, A. Fundamental conceptions of dementia praecox. British Medical Journal, 1906, 2, 757-764.

Meyer, A. The dynamic interpretation of dementia praecox. American Journal of Psychology, 1910, 21, 385.

Natsoulas, T. What are perceptual reports about? Psychological Bulletin, 1967, 67, 249-272.

Nichols, D.C., & Tursky, B. Body image, anxiety and tolerance for experimental pain. Psychosomatic Medicine, 1967, 29, 103-110.

Petrie, A."Individuality in Pain & Suffering" Chicago: University of Chicago Press, 1967.

Pfister, H.O. Disturbances of the autonomic nervous system in schizophrenia and their relations to the insulin, cardiazol, and sleep treatments. American Journal of Psychiatry, 1938 94 ,109.

Phillips, L. Case history data and prognosis in schizophrenia. Journal of Nervous and Mental Disease, 1953, 117, 515-525.

Rapaport, D. Organization and pathology of thought. New York: Columbia University Press, 1951.

Ray, J.S. Electrodermal indications of levels of psychological disturbance in chronic schizophrenia. American Psychologist 1963, 18, 393.

Rodnick, E.H., & Shakow, D. Set in the schizophrenic as measured by a composite reaction time index. American Journal of Psychiatry 1940, 97, 214-225.

Rubin, L.S. Pupillary reactivity as a measure of adrenergic-cholinergic mechanisms in the study of psychotic behavior. Journal of Nervous and Mental Disease, 1960, 130, 386-400.

Rubin, L.S., Giulio, J.B., & Maarten, S.S. Pupillary reactivity in children with recurrent abdominal pain. Psychosomatic Medicine, 1967, 29, 111-120.

Saucer, R.T. A further study of the perception of apparent motion by schizophrenics. Journal of Consulting Psychology, 1958, 22, 256-258.

Saucer, R.T. Chlorpromazine and apparent motion perception by schizophrenics. Journal of Consulting Psychology, 1959, 23, 134-136.

Schluderman, E., & Zubek, J.D. Effects of age on pain sensitivity. Perceptual and Motor Skills, 1962, 14, 295-301.

Schumacher, G., Goodell, H., Hardy, J.D., & Wolff H.G. Uniformity of pain threshold in man. Science, 1940, 92, 110-112.

Shakow, D. Segmental set. Archives of General Psychiatry, 1962, 6, 1-17.

Silverman, J. Perceptual control of stimulus intensity in paranoid and nonparanoid schizophrenia. Journal of Nervous & Mental Disease 1964, 139, 545-549.

Silverman, J. Variations in cognitive control and psychophysiological defense in the schizophrenics. Psychosomatic Medicine, 1967, 29, 225-251.

Streltsova, N.L. The characteristics of some unconditioned reflexes. Proceedings of the All Union theoretical-practical conference dedicated to the centenary of S.S. Korsakov. Moscow: Medgiz, 1955.

Swartz, P. A new method for scaling pain. Journal of Experimental Psychology, 1953, 45, 288-293.

Swets, J.A., Tanner, W.P. & Birdsall T.G. Decision processes in perception. Psychological Review 1961, 68, 301-340.

Thompson, W.R. & Melzack, R. Early environment. Scientific American, 1956, 194, 38-42.

Tizard, J., & Venables, P.H. Reaction time responses by schizophrenics, mental defectives, and normal adults. American Journal of Psychiatry, 1956, 112, 803-807.

Travis, R.C. The diagnosis of character types by visual and auditory thresholds. Psychological Monographs, 1926, 36, 18-37.

Ullmann, L.P. & Eck, R.A. Inkblot perception and the process-reactive distinction. Journal of Clinical Psychology, 1965, 21, 311-313.

Ullman, L.P., & Giovannoni, J.M. The development of a self-report measure of the process-reactive continuum. Journal of Nervous and Mental Disease, 1964, 138, 38-41.

Weckowicz, T.E. Autonomic activity as measured by mecholyl test and size constancy in schizophrenic patients. Psychosomatic Medicine, 1958, 20, 66-71.

Weckowicz, T.E., & Blewett, D.B. Size constancy and abstract thinking in schizophrenic patients. Journal of Mental Science, 1959, 105, 909-934.

Weckowicz, T.E. & Hall, R. Skin histamine reaction in schizophrenic and nonschizophrenic mental patients. Journal of Nervous & Mental Disease 1958, 126, 415-420.

Williams, M. Psychophysiological responsiveness to psychological stress in early chronic schizophrenic reactions. Psychosomatic Medicine, 1953, 15, 456-461.

Wittman, P. A scale for measuring prognosis in schizophrenic patients. Elgin State Hospital Papers, 1941, 4, 20-33.

Wolff, B.B. The relationship of experimental pain tolerance to pain threshold: a critique of Gelfrand's paper. Canadian Journal of Psychology, 1964, 18, 249-253.

Wolff, B.B. & Horland, A.A. Effect of suggestion upon experimental pain: a validational study. Journal of Abnormal Psychology, 1967, 72, 402-407.

A P P E N D I X A

SELF-REPORT SCALE

(Ullmann & Giovannoni, 1964)

Patient's Name _____

Age:_____

Length of Hospitalization:_____

ITEMS:	T	F
When I leave the hospital, I will live with my wife.		
I am married now.		
I have fathered children.		
I have been married.		
Before I was seventeen I had left the home I was raised in and never went back except for visits.		
When I leave the hospital, I will live with one or both of my parents.		
As a civilian I have worked steadily at one job or for one employer for over two years.		
I finished at least one year of education after high school - trade apprenticeship, business school, college, etc.		
Adding up all the money I earned for the last three years, it comes to less than $700, before deductions.		
In my teens I was a member of a group of friends who did things together.		
I hardly ever went over to another kid's house after school or on weekends.		
When I was in school I didn't like Physical Education class.		
Alcohol has nothing to do with my difficulties.		
I have paid regularly to buy a house.		
More than once in the last year I have stayed on after some group meeting and talked with some other members about something that went on.		

	T	F
Shortly before I came into the hospital there was some major change in my life - such as marriage, birth of a baby, death, injury, loss of job, etc.		
I have been depply in love with someone and have told them about it.		
In the kinds of work I do, it is expected that people will stay for at least a year.		
My top wage in the last five years was less than $1.25 an hour.		
I have earned my living for longer than a year at full-time civilian work.		
I have had to stay in a mental hospital for more than one year at a time.		
Within the last five years I have spent more than half of the time in a mental hospital.		
In my teens I was a regular member of a club or organization that had a grown-up who came to meetings. (Scouts, school club, 4-H, church youth club, etc.)		
In my teens there was more than one girl with whom I had more than two dates.		

A P P E N D I X B

INSTRUCTIONS

Part A

This is a test being conducted to measure your reactions. Very shortly you will place your head in this opening. After a 'ready' signal, a light will shine on your forehead for exactly three seconds. Pay close attention to your sensations during this period. I will ask you to describe what you felt.

I will now paint the area of your forehead where the light shines with washable ink which can be removed at the end of the session.

This small temperature lead will be attached to your forehead. The purpose of this is simply to record the temperature of your skin.

Part B

Place your head in this opening and rest your chin here. Please keep your head still and look at the black cross in front of you. This is very important because I am taking a film of your eyes.

As mentioned a light will fall on your forehead. Pay close attention when this happens and tell me as soon as you feel any warmth on your forehead.

The sensations gradually become stronger each time and at one point you will feel a little pricking or jabbing sensation. Report this as soon as you feel it.

The heat will be increased beyond this point step by step until you wish to stop. If you wish to discontinue at any time simply call out 'stop' and the heat will be reduced immediately.

As the heat decreases you are to report that point at which you can no longer feel that pricking or jabbing sensation any more. The heat will be decreased further and as soon as all sensation of warmth has disappeared you are to tell me. It is very simple then,

the heat will be increased until you tell me to stop and then decreased step by step until you no longer feel it.

A P P E N D I X C

RECORDING SHEET

S#_____ Age:_____

Name_____ Temp:_____

Classification._____

Ascending		Descending	
Stimulus #	Temperature	Stimulus #	Temperature
1		1	
2		2	
3		3	
4		4	
5		5	
6		6	
7		7	
8		8	
9		9	
10		10	
11		11	
12		12	
13		13	
14		14	
15		15	
16			

	Ascending	Descending
WDT		
PT		
PTO		

APPENDIX D

Correlation Between BASE, MAX and D

Code:
- G1 - Normals
- G2 - Process Schizophrenics
- G3 - Reactive Schizophrenics
- G4 - Nonschizophrenics
- BASE - Baseline measure of pupil diameter
- MAX - Maximum pupillary response
- D - Difference scores between BASE and MAX

	D - BASE	D - MAX	MAX - BASE
G1	-0.2478	0.3914	0.7945**
G2	-0.1618	0.2276	0.9241**
G3	-0.7662**	-0.5686*	0.9741**
G4	-0.5240*	-0.3177	0.9741**

* $p < .05$ df = 13

** p .01

APPENDIX E

Code:
- MAG - Magnitude of pupillary response
- LAT - Latency of pupillary response
- TEMP - Temperature values for threshold reports
- G1 - Normal subjects
- G2 - Process schizophrenics
- G3 - Reactive schizophrenics
- G4 - Nonschizophrenics
- WDT - Warmth detection threshold
- PT - Pain threshold
- PTO - Pain tolerance

Correlation Matrix for Groups over all Thresholds

	G1	G2	G3	G4
MAG - TEMP	0.4075*	.2831	.4671*	.2413*
LAT - TEMP	.0702	.1948	.3565*	.1910
MAG - LAT	.2238	.3239*	.3874*	.2122
	df=43	df=28	df=40	df=43

* p <.05

Correlation Matrix for G1 at Thresholds

	WDT	PT	PTO
MAG - TEMP	.2968	.2286	.2897
LAT - TEMP	-.0261	-.1145	-.3898
MAG - LAT	.2883	.5104*	-.1119

*p< .05 df=13

Correlation Matrix for G2 at Thresholds

	WDT	PT	PTO
MAG - TEMP	.3005	.5636*	.5465
LAT - TEMP	.5427	.3183	-.3992
MAG - LAT	.2061	.6050*	.2028

*p < .05 df = 8

APPENDIX E cont'd:

Correlation Matrix for G3 at Thresholds

	WDT	PT	PTO
MAG - TEMP	.5831*	.3821	.0335
LAT - TEMP	.4128	.0531	.3105
MAG - LAT	.4602*	.2252	.3335

*p< .05 df=12

Correlation Matrix for G4 at Thresholds

	WDT	PT	PTO
MAG - TEMP	.0561	-.461*	-.0846
LAT - TEMP	.2157	-.499*	.1446
MAG - LAT	.0431	.2410	.1905

*p <.05 df=13

Correlation Matrix for Thresholds over all Groups

	WDT	PT	PTO
MAG - TEMP	.2445*	.1058	.010
LAT - TEMP	.1936	-.231*	.133
MAG - TEMP	.3475**	.4567**	.3069*

*p <.05 df=52

**p <.01

APPENDIX F

Code:

$T_3 - T_1$	-	Amount of pupillary dilation between T_1 & T_3
$T_3 - T_2$	-	Amount of pupillary dilation between T_2 & T_3
$T_2 - T_1$	-	Amount of pupillary dilation between T_1 & T_2
G1	-	Normals
G2	-	Process schizophrenics
G3	-	Reactive schizophrenics
G4	-	Nonschizophrenics
WDT	-	Warmth detection threshold
PT	-	Pain threshold
PTO	-	Pain tolerance
T_1, T_2, T_3	-	Standard temperature scale

Correlation Matrix for G1 at Thresholds

	WDT	PT	PTO
$T_3 - T_1$	-.227	-.419	-.496
$T_3 - T_2$	-.263	.103	.005
$T_2 - T_1$	-.432	-.553*	-.457

*$P < .05$ df = 8

Correlation Matrix for G2 at Thresholds

	WDT	PT	PTO
$T_3 - T_1$	-.474	-.524	-.428
$T_3 - T_2$	-.269	-.022	-.255
$T_2 - T_1$	-.539	-.426	-.495

df = 4

APPENDIX F

Correlation Matrix for G3 at Thresholds

	WDT	PT	PTO
$T_3 - T_1$	.219	-.011	-.341
$T_3 - T_2$	.211	-.097	-.338
$T_2 - T_1$	.098	-.027	-.194

df = 7

Correlation Matrix for G4 at Thresholds

	WDT	PT	PTO
$T_3 - T_1$	-.098	.289	-.167
$T_3 - T_2$	.052	.454	-.073
$T_2 - T_1$	-.303	-.489	-.099

df = 8

APPENDIX G

Summary of Analysis of variance of Maximum Pupillary Response

Source of Variation	Sum of Squares	df	Mean Squares	F
Between groups	14.484	3	4.8280	239.01**
Within groups	1.136	56	.0202	

** $p < .01$

APPENDIX H

Summary of Raw Data

Skin Temperature Recorded at Thresholds:

Normals:

Subject	Baseline	WDT	PT	PTO
51	94	98	99.5	109
50	93.5	94.5	98	99.5
49	91.5	95	97.5	102
48	93	95	97	98
59	92.5	94.5	97	103
52	93.5	95	99	104.5
53	89.5	92	102	107.5
57	92	96	102	107
58	93	95	98.5	103.5
54	87.5	92	98	103.5
55	91	94.5	98.5	102.5
56	90.5	93.5	97.5	101.5
60	90.5	91.5	97.5	99.5
61	91	93	96	99.5
62	94.5	96.5	97.5	99
Process Schizophrenics:				
39	90.5	92.5	103	103.5
37	93	96	102	106.5
23	94	99.5	108.5	113 *
18	93	93		111 *
17	90	91.5		95 *
16	93	98.5		113.5*
14	94.5	96.5	104	111
13	93.5	95		111 *
12	93	97	107	109
11	94.5	96	102	105.5
10	93	96	98	103.5
9	90.5	93.5	104	105.5
5	92	96.5	99.5	102
8	89.5	94.5	112.5	113
24	94.5	96	102	112

* - Subject reached stimulus maximum without reporting PTO

APPENDIX H Cont'd:

Skin Temperature Recorded at thresholds:
Reactive schizophrenics:

Subject	Baseline	WDT	PT	PTO
22	85.5	94.5		106 *
38	92	98	100	104
36	91	98	99	102
44	92	97	101	102
43	91	95.5	99.5	102
21	89.5	91.5	97	103
19	93	94	99	102.5
20	92.5	97	108	111
25	94.5	96	97	102
26	92	95	95	100
15	96.5	97.5	101	102
4	95.5	96.5	99	99
2	84	96.5	99.5	101
1	90	97	98	103
3	92.5	98	100	101
Nonschizophrenics:				
31	90	94.5	98	100
28	91	96	101	103.5
42	91	100	102	104
46	91.5	94	98	101.5
41	89	98.5	99	102.5
35	92.5	94	99.5	103
34	94	94.5	101.5	107
33	92	92.5	99.5	103
32	92	96	100.5	104
30	93	96	99	104.5
29	93.5	97	102	104
47	90.5	94	98.5	102.5
46	91	94	95.5	99.5
45	92.5	96.5	102	104.5
27	92	96	99	102

* - Subject reached stimulus maximum without reporting PTO

APPENDIX H Cont'd:

Pupillary Response in Relation to the Physical Stimulus:

	Subject	T_1	T_2	T_3
Normals:				
	51	0.1	0.4	0.2
	49	0.5	1.0	1.2
	59	0.1	0.2	0.1
	52	0.2	0.8	0.8
	53	0.2	0.3	0.6
	57	0.3	0.8	0.8
	58	0.2	0.5	0.9
	54	0.6	0.6	0.2
	55	0.3	0.4	0.5
	60	0.0	0.0	-0.3
Process Schizophrenics:				
	8	0.0	0.3	0.3
	23	0.2	0.2	0.1
	18	0.0	-0.1	0.0
	16	0.2	0.1	0.2
	13	0.0	0.1	0.2
	12	0.1	0.1	0.0
	11.	-0.2	0.1	0.1
	10	0.1	0.1	-0.1
	9	0.2	0.6	0.6
	5	0.3	-0.2	0.2
Reactive Schizophrenics:				
	22	0.1	0.1	0.2
	38	0.2	0.1	0.1
	44	-0.1	0.3	0.6
	43	0.0	-0.4	0.3
	21	0.0	-0.2	-0.2
	19	-0.1	0.1	0.2
	20	-0.2	0.0	-0.3
	25	0.1	0.1	0.3
	2	0.1	0.3	0.5
	1	0.2	0.4	0.6
Nonschizophrenics:				
	28	0.1	0.4	0.6
	42	0.1	0.2	0.2
	40	0.1	0.4	0.2
	41	0.0	-0.1	-0.1
	35	-0.2	-0.1	-0.4
	34	-0.1	0.1	0.3
	32	0.2	0.3	0.1
	31	-0.2	-0.3	0.4
	30	0.0	0.4	-0.6
	27	0.0	0.2	0.5

APPENDIX H Cont'd:

Pupil Diameter Recorded at Thresholds:

Normals:

Subject	Baseline	WDT	PT	PTO
51	5.6	6.0	6.0	6.0
50	5.8	6.1	6.5	6.7
49	5.1	5.9	6.1	6.3
48	4.7	4.9	4.9	5.0
59	4.9	4.9	5.1	5.0
52	5.2	5.7	6.1	6.3
53	5.5	5.7	6.1	6.4
57	5.7	6.1	6.5	6.6
58	5.1	5.5	5.6	6.0
54	4.1	4.7	4.3	4.9
55	5.7	6.1	5.8	6.2
56	5.1	5.3	5.5	5.7
60	5.4	5.8	5.8	5.8
61	6.0	5.9	6.0	5.7
62	6.1	6.5	6.3	6.6
Process:				
24	4.7	4.7	4.7	4.7
8	4.3	4.7	5.2	5.3
39	3.4	3.1	3.4	3.0
37	3.3	3.5	3.0	3.2
23	3.8	4.0	4.0	-
18	2.6	2.6	-	3.2
16	4.8	5.0	-	-
14	4.1	4.0	4.0	4.1
13	4.0	4.2	-	-
12	4.1	4.1	4.0	4.0
11	2.9	2.5	3.0	2.9
17	3.6	3.4	-	3.4
10	3.9	4.1	4.0	3.7
9	3.4	4.0	4.0	4.0
5	4.6	4.4	4.7	4.8

APPENDIX H Cont'd:

Pupil Diameter Recorded at Thresholds:

Reactive:

Subject	Baseline	WDT	PT	PTO
3	4.5	4.5	5.0	5.2
1	3.1	3.6	3.6	4.0
2	3.7	4.5	4.6	4.7
4	3.7	3.7	4.2	4.2
15	3.5	3.4	3.7	3.8
26	5.9	6.0	5.9	6.1
25	5.1	5.2	5.1	5.4
20	6.0	6.0	6.1	6.0
19	5.0	4.9	5.1	5.2
21	5.2	5.1	5.0	5.1
43	5.8	5.4	6.1	6.1
44	5.3	5.6	5.9	5.9
36	2.9	4.0	4.0	4.1
38	5.9	6.0	6.0	6.0
22	5.2	5.3	-	5.2
Non-Schizophrenic:				
28	4.2	4.6	4.8	4.9
42	3.9	4.1	4.0	4.0
40	4.8	4.8	5.3	5.0
41	4.1	4.0	4.0	4.0
35	4.6	4.3	5.0	4.0
34	3.5	3.5	3.6	4.0
33	3.0	3.1	3.6	3.7
32	3.7	4.0	4.0	4.2
31	3.6	3.3	3.6	4.0
30	5.9	6.0	6.2	6.8
29	5.1	4.7	4.9	5.0
47	4.7	4.8	4.9	5.0
46	4.0	4.2	4.5	4.6
45	3.5	3.4	3.6	3.3
27	3.5	3.6	3.9	4.0